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Adjusting Neonatal Mortality Rates for Birth Weight

Data Evaluation and Methods Research
Series 2, No. 94

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Adjusting Neonatal Mortality Rates for Birth Weight

This report describes how vital statistics can be used to compare birth weight distributions and neonatal mortality among small geographic areas. In particular, the characteristics of the Standardized Mortality Ratio obtained by applying indirect standardization to 1974-1974-77 neonatal mortality and birth weight data are emphasized. Summary tables are presented on geographic distribution of several measures, as well as detailed results for each of 202 Health Service Areas.

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National Center for Health Statistics

ROBERT A. ISRAEL, *Acting Director*

JACOB J. FELDMAN, Ph.D., *Associate Director for Analysis and Epidemiology*

GAIL F. FISHER, Ph.D., *Associate Director for the Cooperative Health Statistics System*

GARRIE J. LOSEE, *Associate Director for Data Processing and Services*

ALVAN O. ZARATE, Ph.D., *Assistant Director for International Statistics*

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ALICE HAYWOOD, *Information Officer*

Division of Analysis

JOEL C. KLEINMAN, Ph.D., *Director*

Cooperation of the U.S. Bureau of the Census

Under the legislation establishing the National Health Survey, the Public Health Service is authorized to use, insofar as possible, the services or facilities of other Federal, State, or private agencies.

In accordance with specifications established by the National Center for Health Statistics, the U.S. Bureau of the Census participated in the design and selection of the sample and carried out the household interview stage of the data collection and certain parts of the statistical processing.

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Symbols used in tables	
- - -	Data not available
. . .	Category not applicable
-	Quantity zero
0.0	Quantity more than zero but less than 0.05
Z	Quantity more than zero but less than 500 where numbers are rounded to thousands
*	Figure does not meet standards of reliability or precision (more than 30 percent relative standard error)
#	Figure suppressed to comply with confidentiality requirements

Adjusting Neonatal Mortality Rates for Birth Weight

by Jean E. Foster and Joel C. Kleinman, Ph.D.,
Division of Analysis

Introduction

As in other industrialized countries where infectious diseases have been controlled, prematurity is the most important factor in determining infant health and survival in the United States.[1] Premature infants include infants born too early (i.e., gestational age 37 weeks or less) as well as those infants born too small as a result of poor intrauterine development. These two groups—preterm and low birth weight—are closely related but do not always coincide. As a result of not being fully developed, premature infants are highly susceptible to a variety of life-threatening conditions such as birth injuries, infections, low blood sugar, and lung problems. The risk of neonatal death is about 20 times greater for premature infants than for full-term newborns.[2]

Although a combined measure of gestational age and birth weight would be the most appropriate indicator of prematurity, there is considerable rationale for focusing on birth weight as a single outcome measure. Analysis of linked birth and death records indicates that mortality is more strongly influenced by birth weight than by gestational age. That is, although infants with shorter gestations generally experience greater mortality at a given birth weight, mortality varies more strongly by birth weight when gestational age is controlled.[3] In their review of the literature on prematurity, Hemminski and Starfield presented additional evidence that birth weight alone explains the variance in perinatal mortality almost as well as a combined index of gestational age and birth weight.[4] Furthermore, the vital statistics data on gestational age (that is derived from date of mother's last menstrual period) has limited reliability, and nonresponse is quite high (20 percent in 1977).[5]

Recent advances in perinatal medicine have led to an unprecedented decline in mortality among low birth weight infants. These advances, together with the proliferation of regionalized perinatal networks, have increased the need for surveillance and monitoring of trends and variations in birth weight-specific perinatal mortality rates. Ideally, this type of monitoring requires a national system of linked birth and death certificates. Although several States do have such systems available, there is no national data base in the United States which can be used to develop estimates of weight-specific mortality rates.

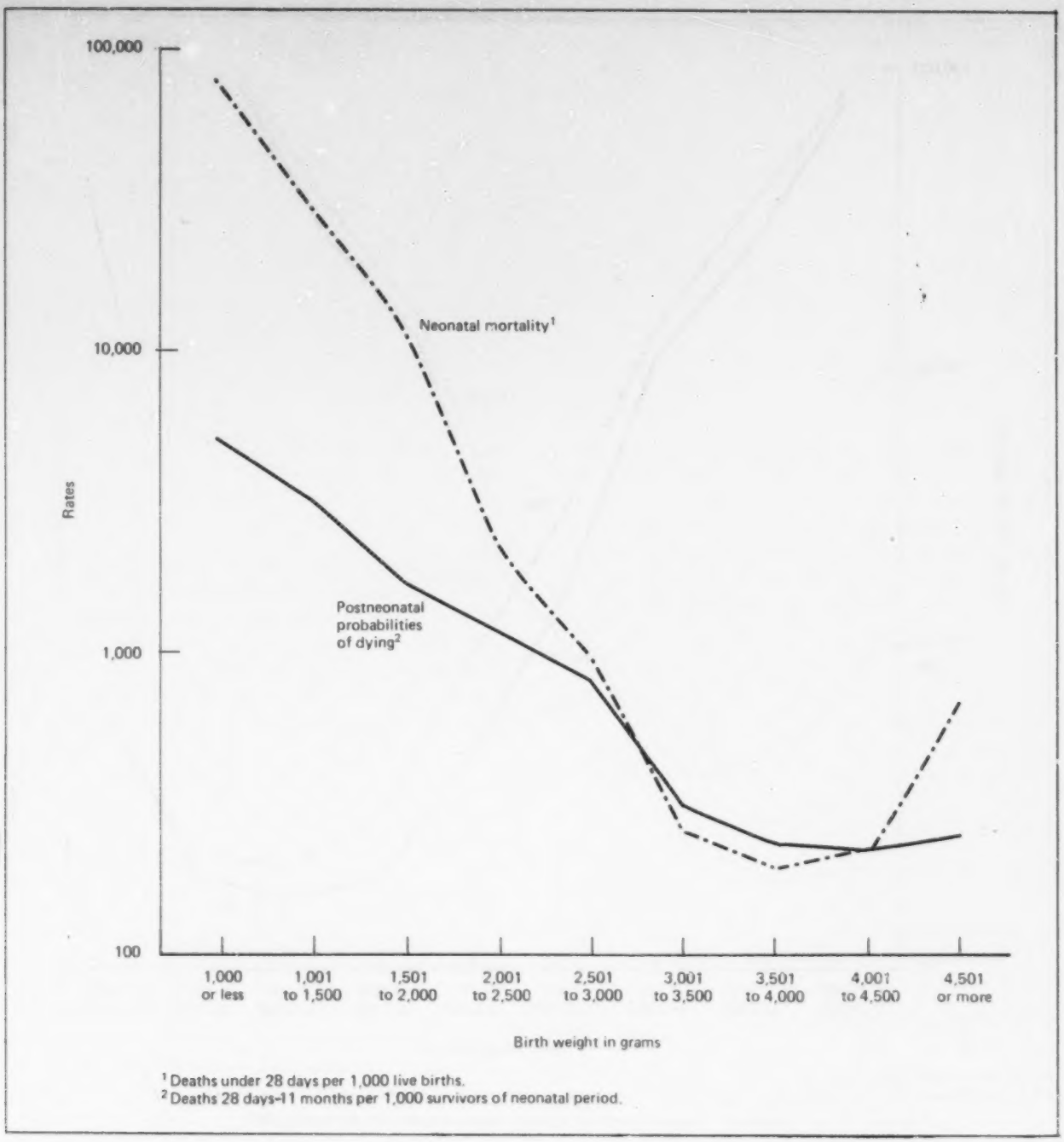
The purpose of this report is to show how vital statistics can be used to compare birth weight distributions and neonatal mortality among small geographic areas within the United States. The Health Service Areas defined under the National Health Planning and Resource Development Act of 1974 are used to illustrate small geographic areas designed for health planning purposes (see appendix I). In particular, several measures that reflect the potential impact of the birth weight distribution on neonatal mortality are presented by Health Service Area for 1974-77. A measure that summarizes the relative level of neonatal mortality, once the effect of differences in the birth weight distribution is eliminated, is also presented. Examples are provided to show how these data can be used to assess infant mortality at the small-area level.

Relationship between birth weight and mortality

Analysis of linked birth and death records from the 1960 live birth cohort (the most recent year that linked records are available nationally) shows that mortality rates were highest for infants 1,000 grams or less and then declined steadily with increasing birth weight up to 4,000 grams. There is a slight upturn in mortality for the heaviest births.[3,6] This relationship between birth weight and mortality is also observed for neonatal and postneonatal mortality separately, although birth weight is more closely associated with the risk of dying within the first month of life. Figure 1 illustrates the steeper curve associated with neonatal mortality, compared with postneonatal mortality among survivors of the neonatal period.

The relationship between birth weight and mortality varies by sex and race of the infant. Although female infants tend to be lighter than male infants, figure 2 (based on 1960 live-birth cohort data) shows that neonatal mortality was greater for males at every birth-weight level except the heaviest (4,501 grams or more). In regard to race, figure 3 shows that in the weight group less than 2,500 grams, all other infants experienced lower neonatal mortality than white infants. However, at higher birth weights, the chances of survival during the neonatal period were considerably better for white than for all other infants.[3] Unfortunately, the 1960 birth cohort data did not consider black births separately. However, these data for "all other" reflect primarily the experience of black infants. Whenever possible, it is preferable to analyze black births separately.

It should be emphasized that the survival advantage associated with black births at low birth weights is not reflected in the overall neonatal mortality for these births. Black infants tended to be lighter on average than white infants, e.g., 12.8 percent of black infants were under 2,500 grams in 1977 compared with 5.9 percent of white infants. Consequently, a birth-weight distribution with a greater proportion of high-risk births, combined with greater mortality at higher birth weights, results in excess neonatal mortality among blacks.



[1] Deaths under 28 days per 1,000 live births.
[2] Deaths 28 days–11 months per 1,000 survivors of neonatal period.

Figure 1. Neonatal mortality rates and post-neonatal probabilities of dying, by birth weight: United States, 1960

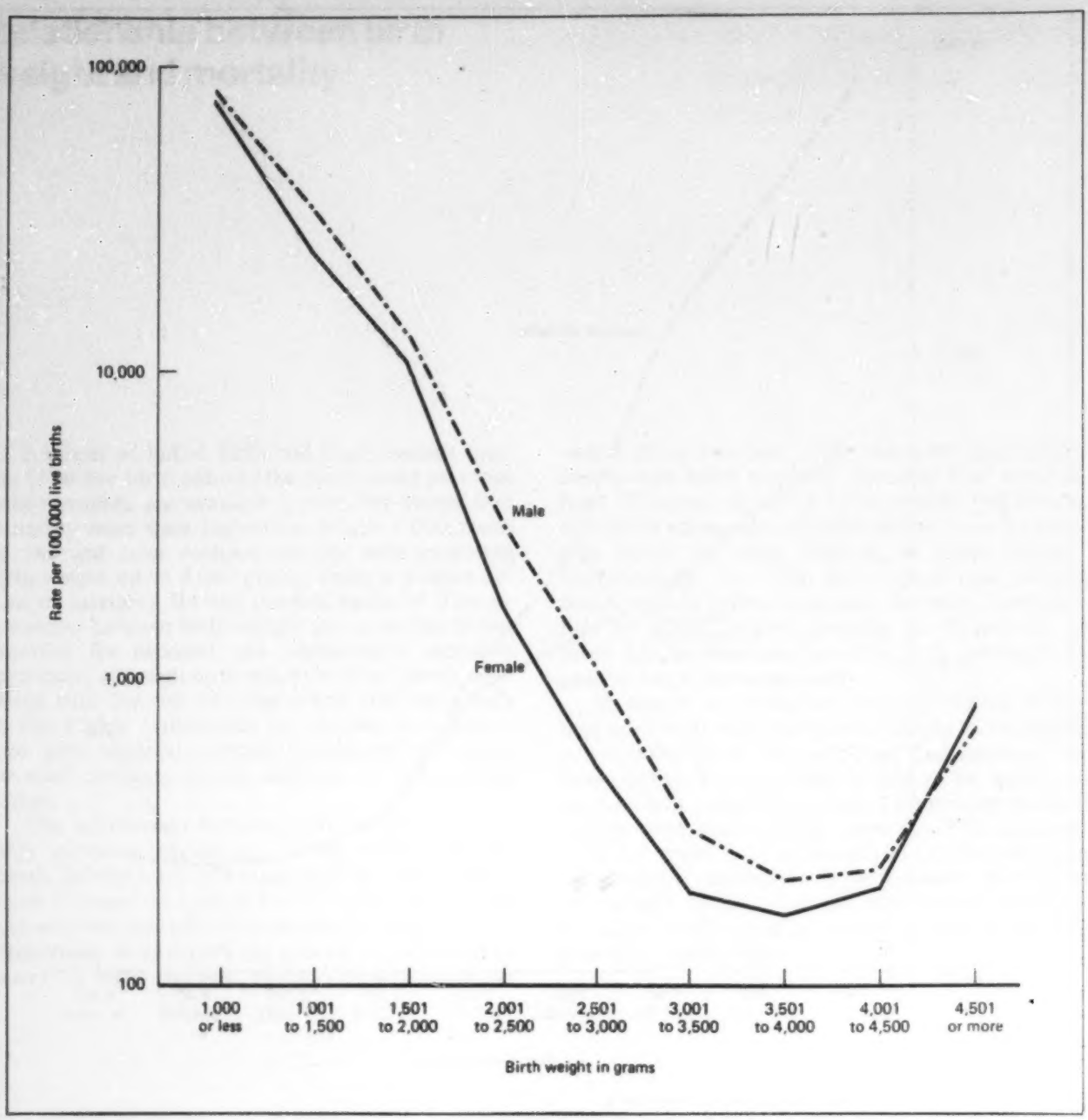


Figure 2. Neonatal mortality by birth weight and sex: United States, 1960

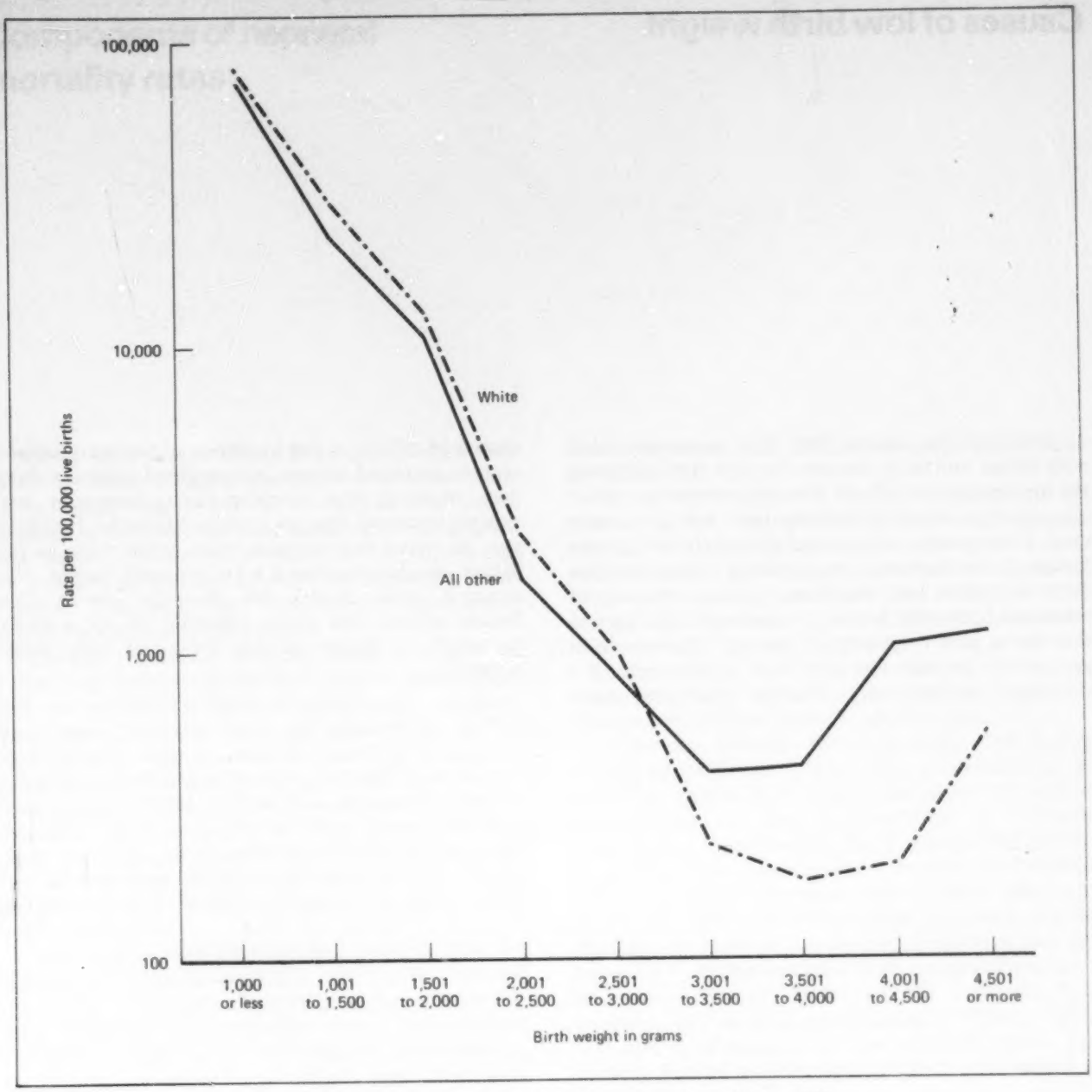


Figure 3. Neonatal mortality by birth weight and race: United States, 1960

Causes of low birth weight

Many of the factors that have been associated with infant mortality operate through their effect on the birth weight of infants. Previous reports identified a number of maternal characteristics that are associated with greater risk of infant death.[2,3,6] These maternal risk factors—race, age-birth order, previous fetal or infant loss, legitimacy status, educational attainment, interval between consecutive births, and the timing and frequency of prenatal care—are also associated with increased risk of low birth weight.[7,8]

Other maternal characteristics that have been shown to influence the incidence of low birth weight include maternal stature, pre-pregnant weight, weight gain, smoking, poor nutrition during pregnancy, and various maternal diseases such as anemia.[4,7] It should also be noted that characteristics attributable to the infant are also associated with low birth weight. For example, male infants are generally heavier than female infants, and plural deliveries are more likely to result in lighter infants compared with single deliveries.

Components of neonatal mortality rates

Since birth weight serves as an intermediate outcome for many variables associated with infant mortality, birth weight can be viewed as a summary measure of the effect of these social and demographic risk factors. To the extent that the risk factors can be ameliorated through health intervention and educational programs, the birth-weight distribution should become more favorable.

However, neonatal mortality rates in an area are a function not only of the birth weight distribution, but also of survival within a birth weight category. Thus when mortality rates are adjusted for differences in birth weight, observed variations are usually ascribed to differences in the perinatal care that infants receive. Several authors have examined perinatal mortality rates in terms of these complementary parts: the "risk" component that affects the composition of the birth weight distribution and the "care" component that affects mortality at given birth weight levels.[9-12]

This partitioning approach is a useful tool in the analysis of neonatal mortality, but a strict division into a risk versus care component is not possible because weight-specific mortality reflects other factors as well as perinatal care.[13] For example, as mentioned earlier, the probabilities of infant death at a given birth weight are also affected by sex, plurality, and gestational age.[3]

Other variables, which are not available on the birth certificate, may also affect birth-weight-specific survival. Madans et al. caution that given two infants with identical birth weights, the chances that one of these infants might die would be higher for "the mother who has had no prenatal care, who is in poor health herself, and who might have drug or alcohol related problems than it would be for the mother whose pregnancy has been monitored since the first trimester and whose health habits are good."[12]

Efforts to improve the birth-weight distribution in an area could also have an effect on weight-specific mortality. Quick et al. recently compared the role of prenatal care on pregnancy outcome in a Health Maintenance Organization and a general population. In addition to documenting a positive relationship between prenatal care and birth weight, they concluded that the impact of prenatal care must also be examined in terms of the medical conditions that are discovered during prenatal care examinations and behavioral changes related to the mother's diet, smoking, and alcohol consumption.[14] These "spin-off" effects of prenatal care are likely to improve the survival chances of infants at any given birth weight.

Definition of measures

In addition to the 1974-77 neonatal mortality rate (the NMR is the number of deaths to infants under 28 days of age divided by the number of live births times 1,000), table 1 contains several measures based on the birth-weight distribution for Health Service Areas (HSA's). Measures are provided for white and black births separately.

The measure of low birth weight (LBW) refers to the percent of all live births in which the infant weighed 2,500 grams or less. Similarly, the measure of very low birth weight (VLBW) is the percent of all live births in which the infant weighed 1,500 grams or less.

The potential impact of the entire birth-weight distribution of an area is summarized in the third measure in table 1—the expected neonatal mortality rate (ENMR). Expected mortality rates are usually used to adjust observed rates for differences in age composition.[15] However, the concept can be extended to adjust for any characteristic (or groups of characteristics) affecting mortality, i.e., birth weight. In particular, the ENMR is a useful summary indicator of the entire birth-weight distribution, rather than just the proportion below a given weight.

The expected neonatal mortality rate is derived by applying a standard set of infant mortality rates to the birth-weight distribution of an area's births:

$$\text{ENMR} = \frac{\sum b_i M_i}{b} = \sum \hat{p}_i M_i$$

where

b_i = births in weight category i

$b = \sum b_i$

M_i = standard neonatal mortality rate for birth weight category i per 1,000 live births

$\hat{p}_i$ = proportion of area's births in birth weight category i

The standard set of rates is usually chosen as the combined mortality experience of all areas being compared, but this is not always possible. Linked birth and death records have not been available nationally since 1960, so the standard mortality rates for the ENMR's presented here are based on linked records obtained from a special study of North Carolina data for 1973-74. (The weight-specific mortality rates were adjusted slightly to account for incomplete matching of birth and death records.) Since infant mortality rates were relatively high in North Carolina compared with the United States as a whole during 1973-74, the ENMR's based on this standard will be higher than if the standard was based on the United States' mortality experience during 1974-77. However, the relative magnitude of ENMR's which have been similarly computed for all the HSA's is not greatly affected by the actual level of the standard rates.[13] Table 2 gives the standard rates used to calculate the ENMR's.

To illustrate the interpretation of an expected neonatal mortality rate, the ENMR for white births in ALA 01 is the neonatal mortality rate that would be "expected" if that area experienced the same birth-weight-specific mortality as 1973-74 North Carolina white births. Thus this ENMR "translates" the entire birth-weight distribution for ALA 01 into a single risk measure that can be compared with the ENMR's of other HSA's to assess the relative importance of the birth-weight distribution on mortality. As will be seen, however, the ENMR is highly correlated with VLBW.

The fourth measure in table 1—the standardized mortality ratio (SMR)—relates an area's observed mortality rate to its expected mortality rate:

$$\text{SMR} = \frac{\text{NMR}}{\text{ENMR}} \times 100$$

The SMR is a comparative index that provides a summary measure of mortality after taking account of

the "risk" composition of the population that affects the observed rate of mortality. Thus the SMR permits the mortality experience of different areas (or time periods) to be compared, controlling for differences in birth-weight distribution.

Turning the previous equation around to bring the NMR term to the left of the equal sign, it can be seen that:

$$NMR = (ENMR \times SMR)/100$$

Thus neonatal mortality for a hospital or geographic area can be evaluated in terms of its ENMR and SMR components. The ENMR can be used to compare the birth weight distributions of different populations, while the SMR compares the weight specific mortality rates, holding the birth weight distribution constant.

In this Note, the SMR was modified to include only those infants weighing at least 500 grams. The probability of dying for infants below 500 grams is virtually certain, particularly during the 1974-77 period under consideration here. The SMR was then calculated as:

$$SMR = \frac{d - b_1}{\sum b_i M_i - b_1} \times 100$$

where

d = all infant deaths

b_1 = births under 500 grams

Kleinman found that the exclusion of the under 500 grams infants yields a measure of neonatal mortality that is more sensitive to preventable deaths.[13]

If the observed rate and the expected rate are the same, the SMR will be 100.0. In the case of white births for ALA 01, the SMR was 93.7, which indicates that the white neonatal mortality rate is 6.3 percent less than what would be expected if that HSA experienced the birth-weight-specific mortality rates of the standard. On the other hand, the SMR of 104.1 for black births in ALA 01 shows that neonatal mortality is 4.1 percent greater than what would be expected if the birth-weight-specific mortality rates of the standard applied.

Since the 1973-74 North Carolina mortality schedule tended to produce somewhat inflated ENMR's, the SMR's presented here will generally be less than 100.0. Again, it is the relative values of the SMR's that are of primary interest, not the actual value of this measure for a particular HSA, and analysis should be directed at the comparison of SMR's among areas. Since the denominator is a weighted average in which the mortality schedule associated with the birth weight distribution is the same for all HSA's, a comparison of SMR's reflects the relative influence of factors that determine infant survival at given birth weights.

There are several assumptions underlying the SMR that require it be used with caution. While controlling for birth weight does control for a large portion of the variation in the risk level of the population, it is important to note that there are several variables that are not available on the birth certificate but could affect weight-specific mortality. A concrete example of a variable which could not be considered in the indirect adjustment is altitude. Women who live at high altitudes have lighter babies.[1] The effect of this phenomenon on the SMR is illustrated clearly by white births in the Denver, Colorado, HSA. This HSA had one of the highest ENMR's and one of the lowest SMR's among all HSA's. The explanation is that Denver's high altitude results in women having babies whose low birth weights are not indicative of subsequent health problems.

Confidence intervals

In order to assess the stability of a statistic such as the neonatal mortality rate, confidence intervals should be calculated. The formula for calculating the standard error (SE) will vary for the types of statistics shown. An approximate formula for the standard error of the NMR is

$$SE\ (NMR) = \sqrt{\frac{1{,}000r}{B}} = 31.623\sqrt{\frac{r}{B}}$$

where

r = rate per 1,000

B = number of births

The 95-percent confidence limits are calculated as follows:

$$\text{Lower limit: } r - 1.96 \times SE\ (r)$$

$$\text{Upper limit: } r + 1.96 \times SE\ (r)$$

The formula for the approximate standard error of a proportion based on natality data (e.g., LBW, VLBW) will vary depending on the source of data. Most States provide the National Center for Health Statistics with 100 percent of their birth certificates, while the remaining States supply only a 50 percent sample. The number of States that provide a 50 percent sample varies from year to year, with an increasing number of States providing information for all birth certificates. Table A shows the appropriate sampling fraction for each State based on the annual number of births and number of years sample data were provided from 1974 through 1977. (Note that if 100 percent natality data is provided for all 4 years,

Table A. Sampling fraction for States providing a 50-percent sample of birth certificates to the National Center for Health Statistics by race: United States, 1974-77

State	Sampling fraction		State	Sampling fraction	
	White	Black		White	Black
Alabama	.75	.75	Montana	1.00	1.00
Alaska	.64	.66	Nebraska	1.00	1.00
Arizona	.50	.50	Nevada	.76	.76
Arkansas	.50	.50	New Hampshire	1.00	1.00
California	.50	.50	New Jersey	.50	.50
Colorado	1.00	1.00	New Mexico	.50	.50
Connecticut	.50	.50	New York[1]	1.00	1.00
Delaware	.50	.50	North Carolina	.87	.87
District of Columbia	.50	.50	North Dakota	.50	.50
Florida	1.00	1.00	Ohio	.63	.60
Georgia	.50	.50	Oklahoma	.88	.88
Hawaii	.50	.50	Oregon	1.00	1.00
Idaho	.64	.63	Pennsylvania	.50	.50
Illinois	1.00	1.00	Rhode Island	1.00	1.00
Indiana	.50	.50	South Carolina	1.00	1.00
Iowa	1.00	1.00	South Dakota	.50	.50
Kansas	1.00	1.00	Tennessee	.87	.88
Kentucky	.76	.76	Texas	.76	.75
Louisiana	.88	.88	Utah	.50	.50
Maine	1.00	1.00	Vermont	1.00	1.00
Maryland	.87	.88	Virginia	.87	.88
Massachusetts	.62	.62	Washington	.50	.50
Michigan	1.00	1.00	West Virginia	.76	.75
Minnesota	.75	.77	Wisconsin	.88	.87
Mississippi	.50	.50	Wyoming	.50	.50
Missouri	1.00	1.00			

[1]New York City provided sample data in 1974, 1975, and 1976.

there is no sampling fraction and $f = 1.00$.) The formula for the standard error is approximated by

$$SE(p) = \sqrt{\frac{pq}{Bf}}$$

where

p = proportion

$q = 1 - p$

B = number of live births

f = sampling fraction

The 95 percent confidence intervals are:

Lower limit: $p - 1.96 \times SE(p)$

Upper limit: $p + 1.96 \times SE(p)$

The approximate lower and upper confidence intervals for the ENMR and SMR are provided in table 1. See appendix I for a more complete explanation of the methodology used.

Distribution of measures

The percentile distributions of the LBW, VLBW, ENMR, and SMR measures are provided in table B. Only HSA's with at least 1,000 births in the specified race group were included in these distributions. The percentile values are the values below which a given proportion of the HSA's will be included. For example, in table B, the 90th percentile value for the percent LBW for white births is 6.87, which indicates that 90 percent of the HSA's had LBW below 6.87 percent for white births during 1974-77.

Table B shows that there is substantial variation in all the measures, although the greater variation among black measures is due in part to their larger standard errors (i.e., smaller number of births upon which measures are based). There is a 51 percent spread between the 5th and 95th percentiles for neonatal mortality among white births and a 97 percent spread among black births. The corresponding spreads for SMR's are somewhat smaller (43 percent among white births and 87 percent among black births) but those for ENMR's considerably smaller (30 percent among white births and 46 percent among black births).

These data suggest that geographic variation in neonatal mortality among HSA's is due in larger part to variations in weight-specific mortality than to variations in birth weight distribution. When ln(SMR) and ln(ENMR) are used as independent variables in a multiple regression with ln(NMR) as the dependent variable, the standardized regression coefficient for ln(SMR) is greater than that for ln(ENMR) (0.90 versus 0.67 among white births, 0.75 versus 0.65 among black births).

Relationship among measures

The Pearson product moment correlation coefficients between selected measures for white and black births are shown in table C. The moderate correlations indicate that HSA's with high levels for white births do not necessarily have high levels for black births. The correlations were highest for the SMR (.54) and lowest for the percent VLBW (.35). These findings suggest that race-specific rates should be used to identify HSA's with unusual values.

Table D shows, by race, the correlation among

Table B. Percentile distributions of selected measures of birth weight and neonatal mortality, by race: U.S. Health Service Areas, 1974-77

Percentile and number of Health Service Areas	White					Black				
	NMR[1]	LBW[1]	VLBW[1]	ENMR[1]	SMR[1]	NMR[1]	LBW[1]	VLBW[1]	ENMR[1]	SMR[1]
5	8.1	5.13	0.73	10.7	67.2	11.5	9.68	1.65	17.1	55.3
10	8.5	5.34	0.78	11.1	70.0	12.3	11.01	1.86	17.7	62.4
20	9.1	5.63	0.83	11.6	72.6	14.6	11.77	1.97	18.6	69.7
30	9.5	5.86	0.86	11.9	75.5	15.7	12.23	2.13	19.5	72.8
40	9.9	6.01	0.88	12.2	76.9	16.5	12.52	2.22	20.4	76.8
50	10.1	6.17	0.91	12.4	79.5	17.4	12.75	2.32	21.2	79.6
60	10.4	6.27	0.94	12.6	81.5	18.2	12.99	2.40	21.7	81.5
70	10.6	6.36	0.96	12.9	84.6	18.8	13.46	2.49	22.2	84.3
80	11.0	6.51	0.99	13.1	87.8	19.9	13.78	2.58	23.0	90.0
90	11.6	6.87	1.03	13.5	92.7	21.3	14.07	2.73	24.1	97.5
95	12.2	7.11	1.07	13.9	96.1	22.7	14.61	2.89	24.9	103.6
Number of HSA's	202	202	202	202	202	156	156	156	156	156

[1]NMR = neonatal mortality rate; LBW = low birth weight; VLBW = very low birth weight; ENMR = expected neonatal mortality rate; SMR = standardized mortality ratio.

Table C. Correlations between white and black measures of birth weight and neonatal mortality in U.S. Health Service Areas:[1] 1974-77

Measure	Correlation coefficient[2]
NMR[3]	.51
LBW[3]	.48
VLBW[3]	.35
ENMR[3]	.40
SMR[3]	.54

[1]Based on 156 Health Service Areas with 1,000 or more black births.
[2]Pearson product-moment correlation coefficient (r).
[3]NMR = neonatal mortality rate; LBW = low birth weight; VLBW = very low birth weight; ENMR = expected neonatal mortality rate; SMR = standardized mortality ratio.

Table D. Correlations among selected measures of birth weight and neonatal mortality in U.S. Health Service Areas, by race: 1974-77

Race and measure	LBW[1]	VLBW[1]	ENMR[1]	SMR[1]
White				
NMR[1]	.402	.418	.466	.759
LBW[1]		.415	.649	-.006
VLBW[1]			.933	-.223
ENMR[1]				-.216
Black				
NMR[1]	.493	.541	.630	.735
LBW[1]		.638	.659	.093
VLBW[1]			.941	-.100
ENMR[1]				-.048

[1]NMR = neonatal mortality rate; LBW = low birth weight; VLBW = very low birth weight; ENMR = expected neonatal mortality rate; SMR = standardized mortality ratio.

selected measures of infant mortality in HSA's. The percent of VLBW births was very highly correlated with the ENMR for both races; the correlations were not as high for LBW. The relationship between LBW and VLBW was only moderate for white births (.42) but stronger for black births (.64). The correlations between LBW and the SMR show no relationship. Most of the other correlations involving LBW and VLBW were below .50. These results support other suggestions that VLBW is a better indicator of infant risk than the usual LBW measure.[10]

Table E lists HSA's with the NMR in the highest quintile and indicates whether the ENMR or SMR was also in the highest quintile. Only 3 of the 42 HSA's listed for white births and 4 of the 32 HSA's listed for black births had both the ENMR and SMR in the highest quintiles. In these situations the entire spectrum of prenatal and perinatal care appears to need improvement.

When only the ENMR is high this suggests that health interventions should be directed at ways to improve the birth weight distribution in the area. For example, a high proportion of births to very young mothers may indicate that sex education or access to family planning services is inadequate for school-age women; programs that reduce the number of teenage pregnancies might, therefore, lower the incidence of low birth weight, which in turn would lower the infant mortality rate.

The situation where only the SMR is high shows that the HSA has relatively poor survival within birth weight groups compared with other HSA's. Here the focus for intervention lies in hospital-based care for newborns. Improvement may be needed in the level of technological innovation, such as perinatal care units, as well as in the efficiency and training of hospital staff. Reference 12 illustrates, using District of Columbia data, how hospital-specific SMR's can be examined to determine possible sources of excess mortality. When differences in the level of risk among hospitals are controlled through birth weight adjustment, variation in hospital rates may be attributable in large part to variation in hospital care.

Note that a substantial portion of the HSA's with ENMR's or SMR's in the highest quintile do not have NMR's in the highest quintile. This suggests that although the crude rate for an area is not particularly high there may be substantial room for improvement in terms of one of the components of the rate. Thus resources and further research can be directed toward the area where intervention is most likely to have an effect.

The list in Table E was generated without reference to the stability of the measures. Before concluding that the measures are indeed at an unusually high or low level, confidence intervals should be calculated to assure that this is not due to chance variation. In addition, the interventions suggested above are meant to be illustrative. Further study of the particular area's social and environmental characteristics and its health system is required before appropriate interventions can be identified.

Table E. Health Service Areas with neonatal mortality rate in highest quintile, by race: 1974-77

Health Service Area	White		Health Service Area	Black	
	ENMR[1]	SMR[2]		ENMR[1]	SMR[2]
ALA 01		X	ALA 04		X
ALA 04	X	X	CON 01	X	X
ALA 05		X	CON 02	X	
ARK 04		X	CON 04	X	
CON 05	X		DC 11	X	X
DC 02	X		FLA 06		X
GA 07		X	ILL 03	X	
ILL 05		X	ILL 07	X	
ILL 09		X	ILL 09	X	X
KAN 01		X	MIC 02	X	
KY 02			NJ 03		X
MC 02		X	NM 01	X	
MO 05		X	NY 01	X	
MON 01		X	NC 01		X
NEV 01	X		OH 02		X
NJ 03	X		OH 03		X
NC 01	X	X	OH 08	X	
NC 02			OH 10		X
NC 05		X	PA 01	X	
NC 06		X	PA 02		X
ND 01		X	PA 06	X	
OH 06			RI 04	X	
PA 01			SC 03		X
PA 03	X		TEN 05		X
PA 05	X		TEX 01		X
PA 06	X		TEX 02	X	X
PA 07		X	TEX 07		X
PA 09	X		TEX 10		X
SC 01	X		TEX 12		X
SC 03		X	VA 05	X	
SD 01		X	INT 05		X
TEN 05			INT 12		
TEX 01		X			
TEX 02		X			
TEX 04		X			
TEX 10		X			
TEX 12		X			
VA 03		X			
WV 01	X	X			
WIS 05		X			
INT 09		X			
INT 15		X			

[1] X indicates expected neonatal mortality rate in highest quintile.
[2] X indicates standardized mortality ratio in highest quintile.

Examples

The following examples illustrate how the data presented in this report can be used to assess neonatal mortality in an area.

ALA 01

In 1974-77, the level of neonatal mortality in ALA 01 appeared to be relatively high for both white and black births. Although the white NMR of 11.2 was in the highest quintile the lower confidence limit extends down to the 50th percentile. This interval was even broader for black births: the observed NMR of 18.8 falls at the 70th percentile; however, the confidence interval ranges from below the 30th to above the 90th percentile.

Turning to measures based on the birth distribution itself, the percent LBW and VLBW, and the ENMR may provide insight into the causes of potentially problematic neonatal rates:

	LBW	*Lower limit*	*Upper limit*	*VLBW*	*Lower limit*	*Upper limit*	*ENMR*	*Lower limit*	*Upper limit*
White	6.56	6.26	6.86	.83	.72	.94	11.9	11.2	12.7
Black	12.37	11.41	13.33	1.93	1.54	2.32	18.2	15.8	20.9

Among white births, it can be concluded that the LBW measure was higher than average (the lower confidence limit was at the 60th percentile). For black births, a somewhat different pattern emerges for the LBW measure. Although the confidence interval covers a larger interval than for white births, it reflects a fair to average rank relative to other HSA's. The VLBW and ENMR measures were at the low end of their distributions for both white and black births in ALA 01.

The SMR is next examined:

	SMR	*Lower limit*	*Upper limit*
White	93.7	85.7	102.3
Black	104.1	88.4	122.7

The SMR's for both white and black births fall above the 90th percentile, with lower confidence limits dropping down only to the 70th percentile. Based on the information presented here, the relatively high NMR in ALA 01 may be attributed to poor weight-specific survival. Further detailed investigation of birth-weight-specific survival in ALA 01 is indicated. As mentioned earlier, reference 12 provides an illustrative example of an investigation of interhospital variation in neonatal mortality as a possible explanation of excess mortality among black infants in the District of Columbia.

MD 05

A look at the data for black births in MD 05 also illustrates the usefulness of exploring a variety of measures to minimize mistaken or misleading conclusions. The NMR of 15.6 appears relatively low, but given the small number of black births, this estimate was very unstable. The SMR of 62.4 was in the lowest quintile, which suggests that given the area's risk composition as reflected in the birth-weight distribution, neonatal mortality fares relatively well compared to other HSA's. Again, the confidence interval is broad, but the upper limit lies below the median value. If analysis stopped at this point, the data for MD 05 would not indicate much cause for concern.

Turning to the ENMR, however, it is evident that the birth-weight distribution among black births is unfavorable. The ENMR of 24.1 lies above the 90th percentile, but its confidence interval extends from below the 50th to well above the 95th percentile; hence, this wide interval weakens the force of the conclusions that may be drawn. Another perspective

can be obtained by focusing on the proportion of births at the low end of the distribution:

LBW	Lower limit	Upper limit	VLBW	Lower limit	Upper limit
15.47	14.24	16.70	3.04	2.46	3.62

The LBW measure falls above the 95th percentile, with a lower confidence limit above the 90th percentile. The VLBW measure covers a wider interval but also points to an extremely unfavorable birth weight distribution. Until additional years of data can be aggregated to produce more reliable mortality estimates, the measures based on the birth distribution, as well as other maternal risk factors derived from natality data, can be used to monitor and evaluate changes in the risk dimension of black neonatal mortality in MD 05.

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TABLE 1. BIRTH WEIGHT AND NEONATAL MORTALITY MEASURES, STANDARDIZED MORTALITY RATIO, AND NUMBER OF LIVE BIRTHS BY HEALTH SERVICE AREA AND RACE: UNITED STATES, 1974-77

HSA	RACE	LOW BIRTH WEIGHT	VERY LOW BIRTH WEIGHT	NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY LOWER LIMIT	EXPECTED NEONATAL MORTALITY UPPER LIMIT	STANDARDIZED MORTALITY RATIO RATIO	STANDARDIZED MORTALITY RATIO LOWER LIMIT	STANDARDIZED MORTALITY RATIO UPPER LIMIT	NUMBER OF LIVE BIRTHS
		PERCENT		PER 1000 LIVE BIRTHS							
INT 06	WHITE	5.90	0.93	10.7	12.6	11.9	13.3	84.4	78.1	91.1	40728
INT 06	BLACK	12.08	2.23	18.3	18.3	15.8	21.1	100.2	83.4	120.4	3823
INT 07	WHITE	5.68	0.98	10.5	12.3	11.8	13.2	83.5	75.4	92.4	25720
INT 07	BLACK	12.16	2.18	18.9	21.1	16.7	26.6	85.6	61.2	119.9	1743
INT 08	WHITE	6.21	0.89	9.6	12.2	11.7	12.8	76.8	72.1	81.8	90028
INT 08	BLACK	13.59	2.30	13.6	22.0	19.9	24.3	55.3	48.1	63.5	13851
INT 09	WHITE	5.08	0.78	11.9	10.8	9.6	12.2	111.4	96.9	128.0	18187
INT 09	BLACK	14.78	3.94	19.7	30.6	12.9	72.7	47.5	14.3	157.3	203
INT 10	WHITE	5.23	0.65	10.2	10.3	9.5	11.2	99.3	88.8	111.0	24760
INT 10	BLACK	4.31	-	-	4.7	...	...	-	...	...	116
INT 11	WHITE	4.97	0.89	9.9	11.5	10.3	12.8	85.2	74.4	97.4	22031
INT 11	BLACK	10.26	5.13	-	48.5	...	...	-	...	...	39
INT 12	WHITE	6.23	0.90	9.6	12.4	11.8	12.9	76.1	71.3	81.3	85439
INT 12	BLACK	13.74	2.49	20.1	23.0	21.3	24.8	86.2	78.7	94.4	14403
INT 13	WHITE	5.91	0.87	9.5	12.0	11.6	12.5	76.8	72.8	81.0	102957
INT 13	BLACK	14.12	2.52	18.9	22.8	21.7	23.9	80.7	75.9	85.7	36054
INT 14	WHITE	6.59	1.12	10.2	14.0	12.7	15.4	71.0	62.8	80.3	24398
INT 14	BLACK	8.09	2.02	11.5	19.6	9.2	42.1	51.6	19.1	139.4	347
INT 15	WHITE	6.24	0.80	11.3	11.5	10.7	12.3	98.0	88.4	108.6	24585
INT 15	BLACK	10.93	2.61	16.3	24.6	16.3	37.1	63.8	40.8	99.9	614

TABLE 1. BIRTH WEIGHT AND NEONATAL MORTALITY MEASURES, STANDARDIZED MORTALITY RATIO, AND NUMBER OF LIVE BIRTHS BY HEALTH SERVICE AREA AND RACE: UNITED STATES, 1974-77

HSA	RACE	LOW BIRTH WEIGHT	VERY LOW BIRTH WEIGHT	NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY LOWER LIMIT	EXPECTED NEONATAL MORTALITY UPPER LIMIT	STANDARDIZED MORTALITY RATIO RATIO	STANDARDIZED MORTALITY RATIO LOWER LIMIT	STANDARDIZED MORTALITY RATIO UPPER LIMIT	NUMBER OF LIVE BIRTHS
		---PERCENT---		---PER 1000 LIVE BIRTHS---							
WAS 01	WHITE	5.50	0.83	9.3	11.3	10.8	11.8	81.8	77.0	86.9	108253
WAS 01	BLACK	10.07	2.22	13.8	21.1	17.9	25.0	65.5	52.4	76.9	6643
WAS 02	WHITE	4.99	0.77	8.8	10.8	9.9	11.9	80.2	71.3	90.2	30248
WAS 02	BLACK	6.59	0.55	-	10.6	...	...	-	...	...	182
WAS 03	WHITE	5.50	0.83	10.1	11.6	10.5	12.8	86.2	76.4	97.2	26330
WAS 03	BLACK	10.70	0.54	13.3	11.7	5.4	25.6	113.4	46.5	276.6	376
WAS 04	WHITE	5.63	0.98	10.1	12.6	11.5	13.9	78.7	69.9	88.7	26482
WAS 04	BLACK	10.64	1.77	13.3	20.1	10.[illegible]	38.9	66.2	32.3	135.9	451
W V 01	WHITE	7.06	0.98	12.4	13.3	12.8	13.8	92.7	88.4	97.2	109720
W V 01	BLACK	11.62	2.25	19.8	20.9	17.7	24.6	94.4	78.7	113.3	4493
WIS 01	WHITE	5.14	0.79	8.3	11.2	10.6	11.9	72.5	66.3	79.3	43687
WIS 01	BLACK	7.93	1.36	11.2	13.9	9.3	20.8	78.1	44.2	137.9	807
WIS 02	WHITE	5.76	0.87	7.8	12.2	11.7	12.7	61.3	57.4	65.4	85383
WIS 02	BLACK	12.66	2.34	13.2	21.3	19.6	23.2	58.5	52.1	65.7	14469
WIS 03	WHITE	5.46	1.08	9.8	13.0	12.1	14.0	73.2	66.0	81.2	26156
WIS 03	BLACK	4.35	4.35	43.5	47.1	7.1	311.5	-	96.7	103.4	23
WIS 04	WHITE	4.90	0.72	9.2	10.5	9.8	11.3	86.3	77.7	95.8	28653
WIS 04	BLACK	6.67	2.22	22.2	25.3	5.2	122.9	87.8	24.8	310.3	45
WIS 05	WHITE	5.35	0.89	11.0	11.9	11.1	12.8	91.8	84.0	100.3	31798
WIS 05	BLACK	14.58	-	-	6.2	...	...	-	...	...	48
WIS 06	WHITE	5.28	0.93	9.3	12.0	11.1	13.1	76.3	67.9	85.6	21742
WIS 06	BLACK	3.45	-	-	4.7	...	...	-	...	...	29
WYO 01	WHITE	8.55	0.92	10.9	13.3	12.3	14.4	80.8	72.3	90.3	27919
WYO 01	BLACK	13.92	1.90	12.5	16.9	8.3	34.5	74.0	29.4	186.6	320
INT 02	WHITE	6.65	0.95	9.7	12.9	11.8	14.0	73.7	65.8	82.4	30684
INT 02	BLACK	13.47	2.41	18.0	22.2	18.4	26.7	70.6	64.4	98.4	4672
INT 03	WHITE	5.82	0.85	9.9	11.6	10.5	12.8	84.6	74.4	96.3	23006
INT 03	BLACK	12.61	2.04	13.6	17.8	16.1	19.7	75.2	66.1	85.4	16275
INT 04	WHITE	6.34	0.98	10.3	12.9	11.8	14.1	79.1	70.7	88.6	28247
INT 04	BLACK	12.88	2.20	15.2	20.3	18.6	22.0	73.[illegible]	66.3	81.2	23357
INT 05	WHITE	5.52	0.91	10.2	12.1	11.7	12.5	83.1	79.7	86.7	141950
INT 05	BLACK	11.40	2.20	23.1	21.2	17.7	25.5	110.0	90.8	133.2	2774

TABLE 1. BIRTH WEIGHT AND NEONATAL MORTALITY MEASURES, STANDARDIZED MORTALITY RATIO, AND NUMBER OF LIVE BIRTHS BY HEALTH SERVICE AREA AND RACE: UNITED STATES, 1974-77

HSA	RACE	LOW BIRTH WEIGHT	VERY LOW BIRTH WEIGHT	NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY LOWER LIMIT	EXPECTED NEONATAL MORTALITY UPPER LIMIT	STANDARDIZED MORTALITY RATIO RATIO	STANDARDIZED MORTALITY RATIO LOWER LIMIT	STANDARDIZED MORTALITY RATIO UPPER LIMIT	NUMBER OF LIVE BIRTHS
		---PERCENT---		----------PER 1000 LIVE BIRTHS----------							
TEX 04	WHITE	6.69	0.92	12.9	12.8	12.0	13.6	100.8	92.9	109.4	35274
TEX 04	BLACK	15.64	2.36	18.9	21.4	17.5	26.1	86.5	66.5	112.6	2542
TEX 05	WHITE	6.43	0.96	10.3	12.7	12.3	13.1	79.6	76.1	83.2	144675
TEX 05	BLACK	13.68	2.44	17.2	21.4	20.2	22.6	79.9	74.7	85.4	34979
TEX 06	WHITE	6.39	0.87	9.5	12.3	11.7	12.9	76.0	70.8	81.4	65017
TEX 06	BLACK	12.29	2.27	15.7	19.9	18.2	21.9	77.0	68.4	86.7	13260
TEX 07	WHITE	6.27	0.88	10.8	12.3	11.4	13.2	87.4	79.4	96.1	30925
TEX 07	BLACK	13.71	2.44	20.9	22.1	20.0	24.4	93.9	83.8	105.2	11342
TEX 08	WHITE	6.23	0.85	10.6	11.9	11.5	12.4	87.9	83.3	92.8	101018
TEX 08	BLACK	11.93	1.73	14.6	18.0	14.2	22.8	80.8	60.9	107.4	2199
TEX 09	WHITE	6.47	0.86	10.0	12.3	11.8	12.8	80.7	76.1	85.7	84618
TEX 09	BLACK	12.60	2.33	16.7	22.5	19.2	26.3	70.0	57.7	84.9	4862
TEX 10	WHITE	6.29	0.90	12.9	12.5	11.5	13.5	103.5	94.0	113.9	25337
TEX 10	BLACK	12.88	2.19	20.5	21.0	18.9	23.4	97.5	86.9	109.2	10143
TEX 11	WHITE	6.52	0.92	9.6	12.5	12.1	12.9	76.2	72.8	79.8	145645
TEX 11	BLACK	13.45	2.54	17.1	23.1	22.0	24.3	71.2	67.0	75.7	43721
TEX 12	WHITE	7.00	0.87	14.7	12.6	11.6	13.7	117.5	106.7	129.4	22474
TEX 12	BLACK	13.65	1.70	24.4	17.7	13.3	23.5	139.6	102.6	190.0	1355
UTH 01	WHITE	5.36	0.64	8.1	10.3	9.8	10.7	78.3	73.7	83.1	130438
UTH 01	BLACK	16.26	2.42	12.8	21.4	12.9	35.3	52.9	25.7	109.2	625
VT 01	WHITE	6.58	1.07	9.4	13.7	12.8	14.6	66.7	60.3	73.9	27197
VT 01	BLACK	13.04	1.45	-	20.1	...	...	-	...	...	70
VA 01	WHITE	6.27	0.91	9.8	12.5	11.7	13.4	76.7	69.3	84.7	28789
VA 01	BLACK	11.75	2.20	15.1	19.2	16.6	22.2	77.4	63.9	93.7	4646
VA 02	WHITE	5.34	0.83	8.1	11.5	10.9	12.2	68.3	62.7	74.5	47990
VA 02	BLACK	12.38	2.56	18.5	23.7	20.8	27.0	73.6	62.8	86.3	5946
VA 03	WHITE	6.92	0.96	12.2	13.1	12.5	13.8	93.0	86.9	99.4	50305
VA 03	BLACK	12.54	2.35	16.8	20.8	18.7	23.1	89.1	78.4	101.3	8832
VA 04	WHITE	5.92	0.89	10.9	11.9	11.1	12.7	91.3	83.2	100.2	30313
VA 04	BLACK	12.47	2.35	19.1	21.0	19.5	22.6	90.0	82.6	98.1	18955
VA 05	WHITE	6.01	1.02	10.5	13.2	12.6	13.9	77.3	72.0	83.0	53534
VA 05	BLACK	12.37	2.56	20.3	23.3	21.9	24.7	84.6	78.7	90.9	27006

TABLE 1. BIRTH WEIGHT AND NEONATAL MORTALITY MEASURES, STANDARDIZED MORTALITY RATIO, AND NUMBER OF LIVE BIRTHS BY HEALTH SERVICE AREA AND RACE: UNITED STATES, 1974–77

HSA	RACE	LOW BIRTH WEIGHT	VERY LOW BIRTH WEIGHT	NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY LOWER LIMIT	EXPECTED NEONATAL MORTALITY UPPER LIMIT	STANDARDIZED MORTALITY RATIO	STANDARDIZED MORTALITY RATIO LOWER LIMIT	STANDARDIZED MORTALITY RATIO UPPER LIMIT	NUMBER OF LIVE BIRTHS
		----PERCENT----		----------PER 1000 LIVE BIRTHS----------							
PA 06	WHITE	6.40	1.02	11.0	13.5	12.9	14.1	80.1	75.9	84.5	123757
PA 06	BLACK	13.64	3.03	21.4	26.7	23.9	29.9	75.2	66.3	85.3	12965
PA 07	WHITE	6.17	0.95	11.6	12.8	11.9	13.9	89.2	81.3	97.8	41131
PA 07	BLACK	11.89	2.35	11.2	18.8	14.0	25.4	51.7	33.1	80.8	1960
PA 09	WHITE	6.66	1.01	11.2	13.2	12.0	14.4	84.1	75.1	94.1	27090
PA 09	BLACK	13.20	0.98	38.9	11.6	7.6	17.6	336.2	194.7	580.7	411
R I 04	WHITE	6.41	1.10	9.9	14.0	13.3	14.8	67.8	62.5	73.6	41465
R I 04	BLACK	12.99	2.75	20.5	25.1	20.9	30.1	79.4	64.3	98.1	2437
S C 01	WHITE	6.83	1.02	11.8	13.5	12.8	14.3	86.6	80.1	93.7	34916
S C 01	BLACK	14.02	2.32	17.0	21.4	19.6	23.4	76.9	68.5	86.4	10727
S C 02	WHITE	6.11	0.88	10.0	11.9	11.2	12.7	83.1	75.6	91.4	29959
S C 02	BLACK	12.86	1.95	15.5	18.8	17.6	20.1	81.5	74.6	89.1	19692
S C 03	WHITE	6.47	0.84	12.3	12.4	11.5	13.4	98.7	89.4	109.0	21441
S C 03	BLACK	13.17	2.33	21.9	21.3	20.1	22.7	103.1	96.2	110.5	22540
S C 04	WHITE	5.84	0.99	9.9	12.8	12.0	13.7	75.3	68.0	83.5	25459
S C 04	BLACK	12.89	2.17	16.0	20.3	19.1	21.7	77.4	71.2	84.1	20571
S D 01	WHITE	5.65	0.90	11.6	12.2	11.3	13.2	95.3	86.8	104.5	39932
S D 01	BLACK	9.81	1.87	18.7	17.7	6.0	51.9	112.4	28.0	451.2	214
TEN 02	WHITE	6.87	1.00	10.6	13.2	12.5	14.0	79.2	73.0	86.1	39820
TEN 02	BLACK	13.89	1.89	16.1	19.5	16.0	23.7	81.4	63.1	105.0	2543
TEN 04	WHITE	6.34	0.87	9.3	12.1	11.6	12.6	75.5	70.6	80.7	69936
TEN 04	BLACK	12.48	2.35	16.8	20.9	19.1	22.9	77.4	62.9	87.0	12419
TEN 05	WHITE	6.08	1.01	11.1	12.7	11.7	13.8	86.9	77.2	97.8	18324
TEN 05	BLACK	12.51	2.40	23.4	21.5	19.0	24.3	109.9	96.1	125.7	6336
TEN 06	WHITE	6.70	0.95	10.5	12.9	12.1	13.9	80.0	72.4	88.3	26848
TEN 06	BLACK	13.17	2.23	16.6	20.7	19.5	21.9	79.0	73.4	85.0	28419
TEX 01	WHITE	7.24	0.87	13.9	12.7	11.7	13.7	110.4	99.9	122.0	22800
TEX 01	BLACK	16.85	1.94	26.1	21.1	15.7	28.3	125.9	91.7	173.0	1187
TEX 02	WHITE	6.95	0.87	13.5	12.2	11.3	13.2	110.9	100.3	122.5	23189
TEX 02	BLACK	14.57	2.62	21.8	23.5	18.9	29.3	92.2	73.4	116.0	2295
TEX 03	WHITE	6.66	0.89	9.9	12.6	11.9	13.5	77.1	70.4	84.4	37200
TEX 03	BLACK	12.83	2.16	16.2	19.5	14.3	26.5	80.9	55.2	118.7	1295

TABLE 1. BIRTH WEIGHT AND NEONATAL MORTALITY MEASURES, STANDARDIZED MORTALITY RATIO, AND NUMBER OF LIVE BIRTHS BY HEALTH SERVICE AREA AND RACE: UNITED STATES, 1974-77

HSA	RACE	LOW BIRTH WEIGHT	VERY LOW BIRTH WEIGHT	NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY RATE	LOWER LIMIT	UPPER LIMIT	STANDARDIZED MORTALITY RATIO	LOWER LIMIT	UPPER LIMIT	NUMBER OF LIVE BIRTHS
		---PERCENT---		---PER 1000 LIVE BIRTHS---							
OH 04	WHITE	5.82	0.89	9.7	12.2	11.5	12.9	77.9	72.0	84.3	57343
OH 04	BLACK	12.87	2.25	18.7	22.2	19.1	25.7	82.3	69.7	97.2	6681
OH 05	WHITE	6.38	0.93	10.6	12.8	12.2	13.4	81.4	76.5	86.6	84340
OH 05	BLACK	13.02	2.48	16.6	21.4	19.1	23.9	74.1	64.3	85.3	11239
OH 06	WHITE	6.44	0.97	11.4	13.1	12.3	14.1	85.9	78.8	93.6	39606
OH 06	BLACK	10.46	1.65	11.5	14.6	10.5	20.4	78.7	48.7	127.3	1214
OH 07	WHITE	6.18	0.96	10.9	12.7	11.9	13.5	85.5	78.9	92.7	47250
OH 07	BLACK	14.86	2.39	17.6	21.2	17.2	26.2	80.8	62.4	104.8	3014
OH 08	WHITE	5.85	0.80	8.7	11.6	10.7	12.5	73.2	65.5	81.9	31565
OH 08	BLACK	13.91	2.65	20.3	23.5	19.9	27.7	84.3	69.5	102.1	4829
OH 09	WHITE	6.37	0.95	10.3	13.1	12.5	13.7	77.1	72.7	81.7	96232
OH 09	BLACK	12.89	2.44	17.6	22.1	20.6	23.8	77.2	70.8	84.1	26823
OH 10	WHITE	6.09	0.90	10.4	12.6	11.7	13.5	81.1	73.9	89.1	38241
OH 10	BLACK	12.75	2.07	20.3	20.8	17.6	24.7	97.0	80.6	116.7	5322
OKL 01	WHITE	6.90	0.95	10.7	13.0	12.6	13.3	81.8	78.4	85.4	141720
OKL 01	BLACK	13.78	2.52	17.3	22.1	20.5	23.8	76.7	69.9	84.1	17086
ORG 01	WHITE	5.23	0.82	8.8	11.4	10.9	12.0	76.0	70.5	81.8	55286
ORG 01	BLACK	11.96	1.74	12.8	17.4	14.5	20.9	71.8	54.6	94.5	2654
ORG 02	WHITE	5.13	0.82	9.0	11.2	10.6	11.7	79.3	73.7	85.3	56799
ORG 02	BLACK	11.57	3.31	21.9	24.7	16.0	38.2	87.4	49.3	155.0	365
ORG 03	WHITE	5.95	0.66	9.0	10.3	9.6	11.2	86.6	76.1	98.5	18775
ORG 03	BLACK	9.86	-	14.1	6.2	4.2	9.3	225.5	32.6	1562.3	71
PA 01	WHITE	6.21	0.98	11.2	13.0	12.5	13.6	84.8	80.6	89.3	138921
PA 01	BLACK	14.40	2.67	20.0	24.0	22.7	25.3	81.1	76.3	86.2	55221
PA 02	WHITE	5.85	1.07	10.5	13.5	12.5	14.6	74.7	67.8	82.3	40954
PA 02	BLACK	10.56	2.09	22.1	18.5	13.0	26.4	122.6	84.7	177.6	1538
PA 03	WHITE	6.39	1.01	11.1	13.3	12.3	14.5	81.9	74.2	90.4	36736
PA 03	BLACK	11.91	1.88	40.5	20.1	9.3	43.3	201.5	104.0	390.7	321
PA 04	WHITE	5.75	0.91	9.1	12.3	11.6	13.0	72.6	67.1	78.5	68348
PA 04	BLACK	12.56	2.49	18.0	21.7	17.8	26.5	81.2	65.0	101.6	4288
PA 05	WHITE	6.27	1.12	12.1	14.2	13.1	15.4	83.7	76.1	92.0	35631
PA 05	BLACK	10.85	3.88	22.9	31.4	15.0	65.7	73.0	35.5	150.0	262

TABLE 1. BIRTH WEIGHT AND NEONATAL MORTALITY MEASURES, STANDARDIZED MORTALITY RATIO, AND NUMBER OF LIVE BIRTHS BY HEALTH SERVICE AREA AND RACE: UNITED STATES, 1974-77

HSA	RACE	LOW BIRTH WEIGHT	VERY LOW BIRTH WEIGHT	NEONATAL MORYALITY RATE	EXPECTED NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY LOWER LIMIT	EXPECTED NEONATAL MORTALITY UPPER LIMIT	STANDARDIZED MORTALITY RATIO RATIO	STANDARDIZED MORTALITY RATIO LOWER LIMIT	STANDARDIZED MORTALITY RATIO UPPER LIMIT	NUMBER OF LIVE BIRTHS
		-----PERCENT----		----------PER 1000 LIVE BIRTHS----------							
N Y 01	WHITE	6.56	1.08	10.7	13.9	13.3	14.4	74.9	70.8	79.3	78031
N Y 01	BLACK	14.78	2.91	23.8	27.3	24.9	30.0	83.6	74.9	93.2	9299
N Y 02	WHITE	6.35	0.94	9.0	12.8	12.2	13.4	67.4	62.6	72.7	56341
N Y 02	BLACK	14.61	2.89	16.6	24.7	22.3	27.4	64.9	56.6	74.4	7150
N Y 03	WHITE	6.26	0.98	10.6	12.9	12.4	13.5	80.3	75.7	85.2	72723
N Y 03	BLACK	11.60	2.32	16.5	20.6	17.8	23.8	77.7	64.3	94.0	4187
N Y 05	WHITE	6.48	1.00	10.0	13.2	12.6	13.7	73.7	69.1	78.7	65878
N Y 05	BLACK	13.46	2.43	19.6	22.9	19.2	27.3	82.9	66.2	103.9	2709
N Y 06	WHITE	6.22	0.88	9.2	12.2	11.8	12.7	72.9	68.5	77.7	77980
N Y 06	BLACK	12.38	2.54	18.3	22.7	20.7	24.8	77.3	68.8	86.8	10605
N Y 07	WHITE	7.29	1.02	10.9	13.7	13.3	14.0	78.2	75.6	81.0	264246
N Y 07	BLACK	13.26	2.42	17.7	21.7	21.1	22.4	79.4	76.6	82.3	145969
N Y 08	WHITE	5.94	0.79	8.4	11.6	11.2	12.0	70.2	66.4	74.2	109568
N Y 08	BLACK	13.43	2.49	19.3	23.1	21.1	25.2	80.4	71.7	90.1	10760
N C 01	WHITE	7.11	0.97	12.0	13.3	12.7	14.1	89.1	83.0	95.7	45858
N C 01	BLACK	14.03	2.51	21.0	21.6	18.9	24.7	97.1	83.0	113.7	5143
N C 02	WHITE	6.50	0.99	11.0	12.9	12.2	13.6	84.3	77.9	91.2	41277
N C 02	BLACK	12.86	2.32	17.7	21.3	19.6	23.2	80.7	72.6	89.8	13827
N C 03	WHITE	6.29	0.98	10.0	12.8	12.1	13.6	76.5	70.2	83.4	37964
N C 03	BLACK	13.59	2.36	19.5	21.5	19.7	23.3	89.6	81.2	99.0	13979
N C 04	WHITE	6.07	0.81	8.9	11.7	10.9	12.6	75.0	67.2	83.8	25692
N C 04	BLACK	12.97	2.13	16.5	19.8	18.2	21.4	82.3	74.3	91.2	14893
N C 05	WHITE	5.98	0.96	11.6	12.6	11.8	13.4	91.8	84.5	99.7	35098
N C 05	BLACK	12.75	2.26	15.1	20.3	19.0	21.8	70.8	64.3	78.0	20528
N C 06	WHITE	6.18	0.94	11.5	12.6	11.9	13.4	91.0	84.2	98.3	39601
N C 06	BLACK	12.62	2.27	18.1	20.2	19.0	21.4	88.7	82.4	95.5	28097
N D 01	WHITE	5.40	0.69	11.1	10.9	9.6	12.2	102.5	89.2	117.7	18351
N D 01	BLACK	6.99	1.08	16.1	15.1	4.5	50.3	106.8	34.0	335.2	186
OH 02	WHITE	6.05	1.03	10.5	13.0	12.3	13.8	79.0	73.3	85.2	55821
OH 02	BLACK	13.73	2.45	19.9	22.0	19.4	24.8	90.2	78.7	103.4	8794
OH 03	WHITE	5.63	0.84	10.5	11.6	10.7	12.7	89.2	79.6	99.9	25354
OH 03	BLACK	11.67	2.41	25.7	22.8	16.2	32.1	114.9	81.2	162.4	1245

TABLE 1. BIRTH WEIGHT AND NEONATAL MORTALITY MEASURES, STANDARDIZED MORTALITY RATIO, AND NUMBER OF LIVE BIRTHS BY HEALTH SERVICE AREA AND RACE: UNITED STATES, 1974–77

HSA	RACE	LOW BIRTH WEIGHT	VERY LOW BIRTH WEIGHT	NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY LOWER LIMIT	EXPECTED NEONATAL MORTALITY UPPER LIMIT	STANDARDIZED MORTALITY RATIO RATIO	STANDARDIZED MORTALITY RATIO LOWER LIMIT	STANDARDIZED MORTALITY RATIO UPPER LIMIT	NUMBER OF LIVE BIRTHS
		----PERCENT----		----------PER 1000 LIVE BIRTHS----------							
MIS 01	WHITE	6.22	0.88	10.9	11.9	11.3	12.5	91.1	85.6	96.9	91951
MIS 01	BLACK	12.23	2.04	19.0	18.6	17.8	19.5	102.4	97.3	107.8	83205
MO 02	WHITE	6.00	0.86	11.3	11.8	11.3	12.3	95.4	89.5	101.8	57622
MO 02	BLACK	12.12	2.16	16.0	18.8	15.6	22.7	83.5	64.7	107.7	2504
MO 04	WHITE	6.06	0.86	10.9	11.8	11.1	12.5	92.4	84.6	100.8	31616
MO 04	BLACK	11.95	3.07	27.3	23.9	14.0	40.8	115.8	68.2	200.2	293
MO 05	WHITE	6.35	0.82	11.3	12.0	11.2	12.8	93.6	85.3	102.7	27248
MO 05	BLACK	13.65	1.86	18.2	17.6	14.7	20.9	103.6	82.2	130.4	2588
MON 01	WHITE	6.56	0.91	11.3	12.7	12.0	13.3	88.6	82.5	95.2	45042
MON 01	BLACK	11.25	1.25	12.5	15.2	7.7	30.0	82.4	35.7	190.1	240
NEB 01	WHITE	5.57	0.80	10.6	11.3	10.7	12.0	92.7	85.4	100.6	38721
NEB 01	BLACK	5.63	1.41	14.1	16.9	4.1	68.7	83.6	25.4	274.7	71
NEB 02	WHITE	4.95	0.70	7.9	10.4	9.6	11.2	75.1	65.8	85.7	20158
NEB 02	BLACK	9.54	2.83	17.7	20.5	11.8	35.7	86.3	46.0	161.7	283
NEV 01	WHITE	7.45	0.95	11.8	14.2	12.9	15.7	82.3	72.0	94.0	13865
NEV 01	BLACK	11.63	2.71	19.4	22.5	11.7	43.3	83.2	36.8	187.9	258
NEV 02	WHITE	6.51	0.85	9.4	12.1	11.0	13.3	76.6	67.1	87.3	18209
NEV 02	BLACK	14.04	2.78	17.4	24.3	20.6	28.8	70.0	57.4	85.5	3669
N H 01	WHITE	6.31	0.97	9.4	12.8	12.2	13.5	71.0	65.6	76.9	45406
N H 01	BLACK	8.66	1.44	14.4	12.9	7.3	22.7	112.3	49.9	252.9	277
N J 01	WHITE	6.06	0.83	8.6	11.9	11.1	12.7	70.5	64.3	77.3	51863
N J 01	BLACK	13.91	2.59	14.9	23.0	19.7	26.8	61.8	51.2	74.6	6722
N J 02	WHITE	6.08	0.87	10.6	12.2	11.5	12.9	85.3	79.2	91.9	70249
N J 02	BLACK	13.40	2.26	15.4	21.0	19.4	22.7	69.7	63.5	76.6	29209
N J 03	WHITE	7.61	0.95	11.5	13.4	12.3	14.7	84.4	75.1	94.9	25311
N J 03	BLACK	15.15	2.58	20.7	22.6	19.4	26.4	90.1	75.5	107.6	6703
N J 04	WHITE	6.20	0.85	8.9	12.3	11.6	13.0	70.4	65.5	75.6	83189
N J 04	BLACK	13.63	2.34	18.7	21.8	19.4	24.6	83.4	72.9	95.4	12158
N J 05	WHITE	6.22	0.95	10.4	13.0	12.2	13.8	78.4	72.8	84.5	66575
N J 05	BLACK	14.07	2.47	19.7	22.9	20.7	25.5	83.8	74.4	94.2	14952
N M 01	WHITE	8.56	0.91	10.6	13.5	12.8	14.2	77.7	72.5	83.4	73095
N M 01	BLACK	12.34	2.59	20.4	24.0	18.2	31.6	83.3	62.1	111.8	2209

TABLE 1. BIRTH WEIGHT AND NEONATAL MORTALITY MEASURES, STANDARDIZED MORTALITY RATIO, AND NUMBER OF LIVE BIRTHS BY HEALTH SERVICE AREA AND RACE: UNITED STATES, 1974-77

HSA	RACE	LOW BIRTH WEIGHT	VERY LOW BIRTH WEIGHT	NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY LOWER LIMIT	EXPECTED NEONATAL MORTALITY UPPER LIMIT	STANDARDIZED MORTALITY RATIO RATIO	STANDARDIZED MORTALITY RATIO LOWER LIMIT	STANDARDIZED MORTALITY RATIO UPPER LIMIT	NUMBER OF LIVE BIRTHS
		-----PERCENT----		----------PER 1000 LIVE BIRTHS----------							
MAS 02	WHITE	6.82	1.02	9.8	14.2	13.1	15.3	66.8	60.3	74.1	31614
MAS 02	BLACK	11.25	2.47	9.9	21.9	14.4	33.4	45.1	26.2	77.6	809
MAS 03	WHITE	6.02	0.86	9.1	12.0	11.5	12.6	74.1	69.4	79.1	89123
MAS 03	BLACK	9.68	1.33	11.9	16.3	12.4	21.6	68.8	47.7	98.8	2270
MAS 04	WHITE	6.28	1.03	10.5	13.4	12.6	14.3	76.1	70.0	82.8	45256
MAS 04	BLACK	11.27	2.18	14.5	19.7	17.5	22.1	70.7	61.0	81.8	10826
MAS 05	WHITE	6.42	1.03	9.5	13.3	12.5	14.1	69.9	64.4	75.9	50717
MAS 05	BLACK	12.59	1.54	18.4	14.2	10.0	20.2	132.0	83.2	209.5	978
MIC 01	WHITE	6.36	0.98	10.0	13.1	12.8	13.4	74.0	71.3	76.8	197946
MIC 01	BLACK	13.69	2.58	18.8	23.0	22.2	23.8	79.4	76.0	82.9	68506
MIC 02	WHITE	5.98	0.94	9.9	12.7	12.0	13.4	76.7	70.7	83.3	37946
MIC 02	BLACK	12.89	3.34	21.3	27.3	22.9	32.6	72.5	57.3	91.7	2397
MIC 03	WHITE	6.25	1.05	9.7	13.4	12.7	14.2	71.0	65.5	77.0	39828
MIC 03	BLACK	13.09	2.67	17.5	23.0	20.4	25.8	72.0	61.3	84.7	5997
MIC 04	WHITE	5.49	0.92	8.8	12.0	11.5	12.6	71.1	66.2	76.5	59552
MIC 04	BLACK	13.86	2.56	17.3	22.7	19.9	25.8	72.8	61.1	86.8	4918
MIC 05	WHITE	6.10	1.03	10.4	13.3	12.5	14.2	76.6	70.0	83.8	30558
MIC 05	BLACK	12.88	2.63	17.7	23.4	20.9	26.2	71.3	61.4	82.8	6372
MIC 06	WHITE	5.94	1.04	10.8	13.2	12.5	13.9	80.4	74.5	86.7	42602
MIC 06	BLACK	13.46	2.50	12.2	21.8	18.7	25.5	50.1	39.0	64.5	3522
MIC 07	WHITE	5.88	0.94	8.8	12.2	11.3	13.3	70.5	61.8	80.4	17032
MIC 07	BLACK	-	-	-	5.4	...	...	-	...	...	15
MIC 08	WHITE	5.54	0.94	10.7	12.4	11.4	13.4	84.8	75.4	95.5	18762
MIC 08	BLACK	9.95	1.42	4.7	10.7	6.5	17.5	44.3	7.3	268.7	211
MIN 04	WHITE	5.17	0.74	9.7	10.7	9.9	11.6	90.4	81.0	100.9	26387
MIN 04	BLACK	9.68	3.23	-	15.5	...	...	-	...	...	33
MIN 05	WHITE	5.66	0.87	9.2	11.8	11.3	12.3	76.9	72.7	81.4	102023
MIN 05	BLACK	12.47	1.97	16.1	19.2	16.2	22.8	81.2	65.9	100.0	4298
MIN 06	WHITE	4.43	0.80	9.6	10.6	9.8	11.4	90.2	81.6	99.7	30821
MIN 06	BLACK	19.05	-	-	13.3	...	...	-	...	...	21
MIN 07	WHITE	4.95	0.90	9.8	11.9	10.9	13.0	81.1	72.1	91.3	22773
MIN 07	BLACK	9.09	-	-	8.8	...	...	-	...	...	44

TABLE 1. BIRTH WEIGHT AND NEONATAL MORTALITY MEASURES, STANDARDIZED MORTALITY RATIO, AND NUMBER OF LIVE BIRTHS BY HEALTH SERVICE AREA AND RACE: UNITED STATES, 1974-77

HSA	RACE	LOW BIRTH WEIGHT	VERY LOW BIRTH WEIGHT	NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY LOWER LIMIT	EXPECTED NEONATAL MORTALITY UPPER LIMIT	STANDARDIZED MORTALITY RATIO RATIO	STANDARDIZED MORTALITY RATIO LOWER LIMIT	STANDARDIZED MORTALITY RATIO UPPER LIMIT	NUMBER OF LIVE BIRTHS
		-----PERCENT----		----------PER 1000 LIVE BIRTHS----------							
IND 03	WHITE	5.91	0.91	10.1	12.4	11.7	13.1	79.9	74.2	85.9	71942
IND 03	BLACK	9.56	1.93	18.8	18.6	13.8	25.0	101.2	74.4	137.7	2236
KAN 01	WHITE	6.02	0.94	12.0	12.5	11.7	13.4	95.8	87.5	104.9	25482
KAN 01	BLACK	12.91	2.47	24.7	20.0	13.4	30.0	123.5	72.4	210.9	364
KAN 02	WHITE	5.34	0.91	10.0	11.9	11.2	12.7	82.7	75.7	90.4	32340
KAN 02	BLACK	11.81	1.91	12.7	17.5	14.5	21.2	68.1	49.8	93.2	2517
KAN 03	WHITE	6.36	0.98	10.5	12.9	12.2	13.5	80.6	74.8	86.9	44613
KAN 03	BLACK	13.88	2.48	19.0	21.5	18.5	24.9	87.1	71.0	106.9	3466
KY 01	WHITE	6.45	0.95	10.0	12.7	12.2	13.2	78.0	73.7	82.5	95104
KY 01	BLACK	12.37	1.86	15.3	18.8	17.2	20.6	80.4	71.9	89.9	14676
KY 02	WHITE	7.01	0.95	11.3	13.1	12.6	13.6	85.6	81.0	90.4	90171
KY 02	BLACK	12.15	2.00	14.2	18.0	15.2	21.2	76.8	61.0	96.7	4155
LA 01	WHITE	6.66	0.84	10.1	12.2	11.6	12.8	81.9	76.3	87.8	57699
LA 01	BLACK	12.75	2.11	18.7	19.6	18.7	20.6	95.2	89.9	100.9	41343
LA 02	WHITE	6.48	0.89	10.5	12.4	11.8	12.9	83.6	78.2	89.3	64685
LA 02	BLACK	13.09	2.25	18.6	20.2	19.2	21.3	91.3	85.7	97.2	35210
LA 03	WHITE	6.13	0.82	10.4	11.8	11.2	12.5	87.1	80.5	94.2	45185
LA 03	BLACK	13.07	2.29	18.1	20.3	19.2	21.4	88.1	82.3	94.2	32467
ME 01	WHITE	5.93	0.88	8.8	12.2	11.7	12.8	70.3	65.5	75.5	60729
ME 01	BLACK	7.02	1.32	4.3	16.9	7.9	35.9	25.7	7.4	89.8	230
MD 01	WHITE	6.06	0.97	10.0	12.6	11.4	13.9	77.6	67.4	89.3	14954
MD 01	BLACK	13.40	2.39	17.5	23.4	15.8	34.8	70.8	43.3	115.7	628
MD 02	WHITE	5.35	0.85	9.6	11.7	10.8	12.7	80.6	71.8	90.5	22451
MD 02	BLACK	9.44	1.89	12.9	18.8	15.4	22.9	66.1	51.8	84.5	3031
MD 03	WHITE	6.05	1.06	10.5	13.4	12.6	14.3	76.5	69.9	83.8	31639
MD 03	BLACK	11.01	2.20	16.8	20.4	18.7	22.1	79.5	71.6	88.3	15162
MD 04	WHITE	6.19	1.00	10.6	13.1	12.5	13.7	79.7	75.0	84.6	73180
MD 04	BLACK	14.04	2.67	18.2	23.7	22.6	25.0	74.4	69.8	79.2	35181
MD 05	WHITE	6.34	0.96	10.0	13.4	12.0	15.0	72.5	61.6	85.4	10523
MD 05	BLACK	15.47	3.04	15.6	24.1	20.8	28.0	62.4	50.9	76.5	3793
MAS 01	WHITE	6.26	1.00	9.2	13.4	12.4	14.4	65.6	59.2	72.7	35151
MAS 01	BLACK	10.65	1.53	15.8	17.6	13.4	23.1	88.8	65.3	120.8	2281

TABLE 1. BIRTH WEIGHT AND NEONATAL MORTALITY MEASURES, STANDARDIZED MORTALITY RATIO, AND NUMBER OF LIVE BIRTHS BY HEALTH SERVICE AREA AND RACE: UNITED STATES, 1974-77

HSA	RACE	LOW BIRTH WEIGHT	VERY LOW BIRTH WEIGHT	NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY LOWER LIMIT	EXPECTED NEONATAL MORTALITY UPPER LIMIT	STANDARDIZED MORTALITY RATIO RATIO	STANDARDIZED MORTALITY RATIO LOWER LIMIT	STANDARDIZED MORTALITY RATIO UPPER LIMIT	NUMBER OF LIVE BIRTHS
		----PERCENT----		----------PER 1000 LIVE BIRTHS----------							
GA 02	WHITE	7.47	0.82	10.8	12.6	11.6	13.8	84.7	75.8	94.8	28324
GA 02	BLACK	14.31	2.56	11.7	23.8	19.3	29.4	46.5	35.3	61.2	3511
GA 03	WHITE	6.50	0.90	8.5	12.5	11.9	13.1	67.0	62.5	71.8	86444
GA 03	BLACK	13.78	2.75	18.1	24.2	22.7	25.8	71.9	66.9	77.2	40892
GA 06	WHITE	5.96	0.89	10.4	11.4	10.3	12.6	91.5	79.9	104.7	20019
GA 06	BLACK	12.22	2.03	12.5	19.1	17.4	21.1	63.1	55.9	71.2	19242
GA 07	WHITE	6.35	0.86	11.1	12.2	11.0	13.4	90.9	80.5	102.7	23733
GA 07	BLACK	12.36	1.83	12.3	18.2	16.2	20.4	63.6	54.8	73.8	14465
HAW 03	WHITE	5.86	1.06	8.9	13.0	11.6	14.6	67.2	57.8	78.2	17190
HAW 03	BLACK	8.61	1.29	9.3	13.1	9.0	19.2	67.4	38.5	118.1	1396
IDA 01	WHITE	5.71	0.75	8.8	10.9	10.4	11.5	79.6	73.8	85.8	66519
IDA 01	BLACK	6.25	-	8.8	4.9	4.3	5.6	178.5	44.8	711.5	228
ILL 01	WHITE	5.55	0.82	10.2	11.7	11.0	12.4	86.5	79.0	94.7	31401
ILL 01	BLACK	11.79	1.90	16.5	19.0	15.5	23.2	84.5	64.8	110.3	2367
ILL 02	WHITE	6.13	1.05	10.2	13.4	12.7	14.2	73.5	67.7	79.9	39776
ILL 02	BLACK	12.43	2.42	19.1	22.5	18.7	26.9	83.9	67.7	103.9	2559
ILL 03	WHITE	6.02	0.94	10.2	12.4	11.7	13.2	81.0	73.9	88.8	31542
ILL 03	BLACK	14.19	3.19	26.0	31.2	24.6	39.5	73.9	53.5	102.0	1383
ILL 04	WHITE	6.29	0.99	10.3	12.9	12.2	13.6	78.4	72.4	84.9	42360
ILL 04	BLACK	13.71	2.83	19.0	24.9	21.6	28.7	71.3	58.8	86.4	3899
ILL 05	WHITE	6.05	0.88	11.6	12.1	11.4	12.8	96.1	88.4	104.5	31722
ILL 05	BLACK	12.05	1.87	15.0	19.8	15.6	25.3	74.2	55.4	99.4	1663
ILL 07	WHITE	5.95	0.97	10.9	12.8	12.5	13.1	83.2	80.5	85.9	240153
ILL 07	BLACK	13.98	2.80	20.9	24.4	23.8	25.1	83.6	81.0	86.2	115586
ILL 08	WHITE	5.45	0.86	10.3	11.7	11.1	12.3	87.8	81.5	94.6	46232
ILL 08	BLACK	11.77	2.37	16.6	21.0	18.6	25.2	71.8	58.1	88.8	3800
ILL 09	WHITE	5.89	0.95	11.4	12.6	11.8	13.5	89.3	81.1	98.3	26794
ILL 09	BLACK	13.41	2.61	24.2	24.1	20.9	27.9	100.2	85.2	117.8	3807
IND 01	WHITE	5.74	0.91	10.7	12.3	11.7	12.9	86.5	81.6	91.6	109235
IND 01	BLACK	11.46	2.32	18.7	21.9	19.8	24.3	82.9	74.1	92.8	17779
IND 02	WHITE	5.95	0.92	9.1	12.4	11.9	13.0	70.7	66.5	75.1	113724
IND 02	BLACK	12.69	2.26	15.8	20.8	18.7	23.2	73.3	64.5	83.3	14961

TABLE 1. BIRTH WEIGHT AND NEONATAL MORTALITY MEASURES, STANDARDIZED MORTALITY RATIO, AND NUMBER OF LIVE BIRTHS BY HEALTH SERVICE AREA AND RACE: UNITED STATES, 1974-77

HSA	RACE	LOW BIRTH WEIGHT	VERY LOW BIRTH WEIGHT	NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY LOWER LIMIT	EXPECTED NEONATAL MORTALITY UPPER LIMIT	STANDARDIZED MORTALITY RATIO RATIO	STANDARDIZED MORTALITY RATIO LOWER LIMIT	STANDARDIZED MORTALITY RATIO UPPER LIMIT	NUMBER OF LIVE BIRTHS
		PERCENT		PER 1000 LIVE BIRTHS							
CON 01	WHITE	5.95	0.95	9.9	12.6	11.5	13.8	75.5	67.1	84.9	30434
CON 01	BLACK	12.98	2.80	22.6	24.1	20.2	28.9	92.6	76.4	112.3	5218
CON 02	WHITE	6.36	0.84	10.3	12.4	11.3	13.5	81.8	73.0	91.5	30296
CON 02	BLACK	13.82	3.35	20.8	28.9	24.4	34.4	66.9	55.4	80.9	5200
CON 03	WHITE	5.76	0.89	10.2	12.6	11.3	14.0	78.5	68.7	89.8	22422
CON 03	BLACK	14.71	2.15	15.7	22.1	15.1	32.5	65.8	41.5	104.4	1210
CON 04	WHITE	6.39	1.06	10.1	13.6	12.6	14.8	71.2	64.2	78.9	37223
CON 04	BLACK	14.58	3.16	22.4	28.1	23.6	33.4	74.8	61.4	91.2	5048
CON 05	WHITE	6.70	1.40	14.0	16.8	13.8	20.3	79.8	63.6	100.0	6287
CON 05	BLACK	6.25	-	-	4.7	...	...	-	...	...	64
DEL 01	WHITE	6.27	0.96	9.3	12.9	11.7	14.2	70.0	61.8	79.4	25617
DEL 01	BLACK	13.89	2.48	15.2	21.4	18.4	24.8	68.4	56.9	82.2	7285
D C 02	WHITE	6.90	1.40	13.8	15.8	12.9	19.2	86.3	68.9	108.2	5719
D C 02	BLACK	14.01	2.73	22.7	24.5	22.6	26.0	92.8	86.2	99.9	33382
FLA 01	WHITE	5.86	0.90	10.3	12.0	11.4	12.7	84.3	77.5	91.7	37423
FLA 01	BLACK	12.23	1.97	17.5	18.6	17.2	20.2	93.8	84.9	103.7	13752
FLA 02	WHITE	6.24	0.97	9.7	12.7	11.8	13.7	75.9	68.2	84.4	22668
FLA 02	BLACK	11.59	1.89	15.8	17.7	15.9	19.6	88.6	77.7	101.1	8881
FLA 03	WHITE	6.40	1.13	9.5	14.3	13.6	15.1	65.7	60.8	70.9	39236
FLA 03	BLACK	12.70	2.64	17.8	23.5	21.8	25.3	73.8	67.5	80.7	15101
FLA 04	WHITE	6.58	1.04	9.7	13.3	12.7	13.9	71.6	66.7	76.9	53051
FLA 04	BLACK	13.83	2.58	19.6	23.3	21.5	25.2	82.2	74.5	90.7	13142
FLA 05	WHITE	6.18	0.83	8.7	11.8	11.1	12.5	72.4	65.8	79.5	33731
FLA 05	BLACK	12.07	2.02	13.8	18.9	17.2	20.8	71.2	62.3	81.4	9666
FLA 06	WHITE	6.58	1.01	10.5	12.9	12.1	13.6	80.8	73.9	88.4	31851
FLA 06	BLACK	13.09	2.40	21.9	22.1	20.0	24.4	99.3	89.0	110.8	8707
FLA 07	WHITE	6.91	1.00	10.4	13.4	12.5	14.4	75.6	67.6	84.5	21406
FLA 07	BLACK	13.20	2.50	18.9	21.9	20.0	24.0	85.0	76.1	94.9	9817
FLA 08	WHITE	6.41	0.88	9.2	12.6	11.8	13.5	70.3	63.2	78.2	26796
FLA 08	BLACK	13.61	2.62	18.7	22.1	20.2	24.2	82.8	73.5	93.4	9500
FLA 09	WHITE	5.96	0.96	8.9	12.7	12.1	13.4	68.0	63.0	73.3	49980
FLA 09	BLACK	12.51	2.52	16.0	22.2	20.9	23.6	70.0	64.6	75.8	22561

TABLE 1. BIRTH WEIGHT AND NEONATAL MORTALITY MEASURES, STANDARDIZED MORTALITY RATIO, AND NUMBER OF LIVE BIRTHS BY HEALTH SERVICE AREA AND RACE: UNITED STATES, 1974-77

HSA	RACE	LOW BIRTH WEIGHT	VERY LOW BIRTH WEIGHT	NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY LOWER LIMIT	EXPECTED NEONATAL MORTALITY UPPER LIMIT	STANDARDIZED MORTALITY RATIO RATIO	STANDARDIZED MORTALITY RATIO LOWER LIMIT	STANDARDIZED MORTALITY RATIO UPPER LIMIT	NUMBER OF LIVE BIRTHS
		-----PERCENT----		----------PER 1000 LIVE BIRTHS----------							
CAL 02	WHITE	5.65	0.75	8.3	11.1	10.4	11.9	73.6	67.3	80.6	54937
CAL 02	BLACK	10.71	1.99	12.1	17.2	14.2	20.8	68.9	54.1	87.7	5044
CAL 03	WHITE	5.33	0.74	8.1	10.9	9.9	12.1	73.2	64.3	83.1	27549
CAL 03	BLACK	9.40	1.63	12.6	17.3	12.8	23.5	73.0	51.8	102.8	2215
CAL 04	WHITE	5.77	1.04	8.1	14.0	12.9	15.1	46.7	41.5	52.6	44366
CAL 04	BLACK	11.68	2.15	12.2	20.4	18.0	23.1	55.1	46.9	64.7	11717
CAL 05	WHITE	5.42	0.81	8.0	11.2	10.5	11.9	69.8	64.1	75.9	64737
CAL 05	BLACK	12.67	2.18	10.8	19.6	17.8	21.6	52.8	46.4	60.1	18475
CAL 06	WHITE	5.55	0.73	7.8	10.7	9.9	11.5	72.3	65.1	80.2	42481
CAL 06	BLACK	12.67	1.99	9.9	17.1	13.3	22.0	58.0	40.2	83.7	2420
CAL 07	WHITE	5.72	0.93	8.2	12.3	11.5	13.1	65.1	59.8	70.9	60664
CAL 07	BLACK	9.13	1.31	9.5	14.0	11.0	17.8	66.7	48.6	91.6	3678
CAL 08	WHITE	4.88	0.87	8.5	11.1	10.2	12.1	75.2	67.1	84.3	33589
CAL 08	BLACK	11.77	2.55	17.2	23.0	16.8	31.6	66.5	44.8	98.6	1806
CAL 09	WHITE	5.67	0.80	9.9	11.5	10.9	12.2	85.8	80.0	92.0	77291
CAL 09	BLACK	11.84	2.31	16.6	21.2	17.4	25.8	77.1	62.2	95.7	4688
CAL 10	WHITE	5.14	0.70	7.8	10.6	9.8	11.4	72.2	64.8	80.4	41313
CAL 10	BLACK	8.53	1.38	13.2	13.9	9.6	20.1	94.5	62.1	143.9	1596
CAL 11	WHITE	5.40	0.78	8.4	11.0	10.7	11.3	75.8	73.2	78.4	361052
CAL 11	BLACK	11.69	1.95	15.3	18.3	17.4	19.2	82.6	77.8	87.7	69102
CAL 12	WHITE	5.74	0.78	8.5	11.2	10.6	11.9	74.8	69.3	80.7	74372
CAL 12	BLACK	11.99	1.99	11.5	18.0	15.1	21.5	61.0	48.1	77.4	5641
CAL 13	WHITE	5.31	0.82	8.6	11.3	10.7	11.9	74.9	70.0	80.1	95655
CAL 13	BLACK	9.18	1.76	7.8	16.7	12.2	23.0	35.2	20.5	60.6	2055
CAL 14	WHITE	5.41	0.87	8.2	11.6	11.0	12.3	68.4	63.7	73.4	90070
CAL 14	BLACK	11.69	1.98	14.2	19.5	16.7	22.7	70.2	58.5	84.3	7891
COL 01	WHITE	8.32	1.03	8.5	14.2	13.8	14.6	57.0	53.8	60.4	98975
COL 01	BLACK	14.87	2.38	14.2	22.0	19.4	25.0	61.4	51.6	73.2	5359
COL 02	WHITE	8.91	1.07	10.3	14.5	13.8	15.2	69.6	64.1	75.6	39022
COL 02	BLACK	14.16	2.73	14.7	22.9	18.6	28.1	59.6	43.4	81.9	1833
COL 03	WHITE	8.57	0.95	10.4	13.6	12.5	14.7	76.4	67.0	87.2	14515
COL 03	BLACK	9.09	-	-	7.4	...	...	-	...	...	33

TABLE 1. BIRTH WEIGHT AND NEONATAL MORTALITY MEASURES, STANDARDIZED MORTALITY RATIO, AND NUMBER OF LIVE BIRTHS BY HEALTH SERVICE AREA AND RACE: UNITED STATES, 1974-77

HSA	RACE	LOW BIRTH WEIGHT	VERY LOW BIRTH WEIGHT	NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY RATE	EXPECTED NEONATAL MORTALITY LOWER LIMIT	EXPECTED NEONATAL MORTALITY UPPER LIMIT	STANDARDIZED MORTALITY RATIO RATIO	STANDARDIZED MORTALITY RATIO LOWER LIMIT	STANDARDIZED MORTALITY RATIO UPPER LIMIT	NUMBER OF LIVE BIRTHS
		PERCENT		PER 1000 LIVE BIRTHS							
ALA 01	WHITE	6.56	0.83	11.2	11.9	11.2	12.7	93.7	85.7	102.3	35460
ALA 01	BLACK	12.37	1.93	18.8	18.2	15.8	20.9	104.1	88.4	122.7	6050
ALA 02	WHITE	6.32	1.01	10.2	12.4	10.9	14.3	81.5	67.2	98.9	7837
ALA 02	BLACK	11.52	1.92	16.0	18.0	15.6	20.8	88.2	74.2	104.9	6180
ALA 03	WHITE	6.27	0.93	10.9	12.3	11.6	13.2	87.8	80.5	95.9	35391
ALA 03	BLACK	12.96	2.12	15.4	18.8	17.4	20.4	80.5	72.5	89.4	17813
ALA 04	WHITE	6.61	1.10	13.1	14.1	13.0	15.3	92.9	83.9	102.8	21903
ALA 04	BLACK	12.69	2.55	20.8	21.7	19.3	24.3	95.9	84.2	109.3	8059
ALA 05	WHITE	5.61	0.77	11.1	11.0	10.2	12.0	100.1	90.3	110.9	25412
ALA 05	BLACK	11.75	2.01	19.7	18.8	17.4	20.3	105.2	96.2	114.9	19398
ALA 06	WHITE	5.86	0.78	9.1	11.3	10.5	12.2	79.5	71.1	89.0	26806
ALA 06	BLACK	11.66	1.89	17.6	17.7	16.4	19.0	99.9	91.8	108.7	23311
ALK 01	WHITE	4.98	0.68	8.4	10.4	9.4	11.4	79.8	69.8	91.1	22112
ALK 01	BLACK	9.49	1.82	24.2	14.1	9.6	20.7	183.1	121.2	276.5	993
ARI 01	WHITE	6.01	0.89	10.0	12.1	11.5	12.8	81.7	76.3	87.5	82423
ARI 01	BLACK	12.55	2.70	18.8	21.7	18.0	26.2	85.9	69.5	106.2	4517
ARI 02	WHITE	6.25	0.81	8.0	11.8	10.7	12.5	67.9	60.7	76.0	36326
ARI 02	BLACK	9.93	1.55	7.1	13.6	10.0	18.3	52.1	30.0	90.3	1557
ARI 03	WHITE	7.27	0.85	9.1	12.5	10.7	14.5	72.6	59.2	89.1	9218
ARI 03	BLACK	11.46	2.08	15.5	21.1	7.7	57.6	48.3	7.3	319.2	194
ARI 05	WHITE	6.82	0.64	9.6	10.3	8.9	11.9	93.9	75.2	117.2	7890
ARI 05	BLACK	10.17	-	4.2	8.5	5.8	12.4	49.9	7.2	344.6	236
ARK 01	WHITE	6.88	0.92	9.8	12.6	11.6	13.6	77.1	69.6	85.5	35295
ARK 01	BLACK	12.82	3.38	16.9	25.7	19.6	33.7	65.6	48.5	88.7	2017
ARK 02	WHITE	6.26	0.85	10.6	11.9	10.9	13.0	88.0	78.4	98.8	27282
ARK 02	BLACK	12.52	1.89	14.8	18.1	15.8	20.6	80.4	68.7	94.1	10424
ARK 03	WHITE	6.26	0.79	9.4	11.7	10.6	12.9	79.5	69.7	90.6	23071
ARK 03	BLACK	13.00	2.08	15.9	18.7	16.3	21.3	83.9	71.4	98.6	9547
ARK 04	WHITE	6.35	0.89	11.3	12.7	11.3	14.3	88.0	76.2	101.6	17557
ARK 04	BLACK	12.62	2.13	15.1	19.5	17.4	21.9	76.5	66.7	87.8	12687
CAL 01	WHITE	6.02	0.73	7.8	10.9	10.0	11.9	70.2	61.9	79.6	30248
CAL 01	BLACK	9.30	1.03	10.3	10.4	6.5	16.7	99.1	37.4	262.5	387

Table 2. Neonatal mortality rates by race and birth weight: North Carolina, 1973-74

Birth weight	*White*	*Black*
	Rate per 1,000 live births	
500 grams or less	1,000.00	1,000.00
501-1,000	897.46	868.04
1,001-1,500	464.66	323.46
1,501-2,000	151.83	90.63
2,001-2,500	31.91	17.08
2,501-3,000	5.95	5.10
3,001-3,500	3.24	3.43
3,501-4,000	2.53	3.13
4,001-4,500	2.47	5.86
Above 4,500	5.17	23.34

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Appendix I. Health Service Area codes

Health Service Areas (HSAs) designated under the National Health Planning and Resources Development Act of 1974 are defined in reference 16. Figures I-III illustrate these areas. The HSA codes used in this report have been modified to be consistent with county boundaries. The codes in table 1 are the same as those used by the Health Resources Administration to produce the Area Resource File (Version 12).[17] As a result of the redefinition, there are a total of 202 HSA's for which 1974-77 low birth weight and neonatal mortality statistics have been calculated. This excludes Puerto Rico and other areas that are comprised of small parts of counties that cannot be defined.

The exceptions to the official HSA designations are as follows:

(a) The States requesting exemption from designating HSA's are redefined as follows:

Official HSA code	*Redefined HSA code*
None	DC 02
None	HAW 03
None	RI 04

(b) Interstate HSA's are listed with State name as INT (for interstate) on the last page of the printout. The 14 interstate HSA's are defined as follows:

Official HSA code	*Redefined HSA code*
GA 01, TN 03	INT 02
GA 04, SC 05	INT 03
GA 05, AL 07	INT 04
IA 01, NE 04	INT 05
NE 03, IA 02	INT 06
IA 03, IL 10	INT 07
OH 01, KY 03	INT 08
ND 02, MN 01	INT 09
WI 07, MN 02	INT 10
ND 03, MN 03	INT 11
MO 01, KS 04	INT 12
MO 03, IL 11	INT 13
NY 04, PA 08	INT 14
TN 01, VA 06	INT 15

(c) HSA's officially listed as including parts of counties are redefined to include the following complete counties:

Official HSA code	*Counties included*
AK 01	All divisions in Alaska
AZ 01	Gila, Maricopa, Pinal
AZ 02	Cochise, Greenlee, Pima, Santa Cruz, Graham
AZ 03	Coconino, Yavapai, Apache, Navajo (includes AZ 04)
AZ 05	Mohave, Yuma
CT 01	Fairfield
CT 02	New Haven
CT 03	Middlesex, New London, Windham
CT 04	Hartford, Tolland
CT 05	Litchfield
IL 06	Area is not defined. Chicago is included in IL 07.
IL 07	Cook, Du Page
MA 01	Berkshire, Franklin, Hampden, Hampshire
MA 02	Worcester
MA 03	Essex, Middlesex
MA 04	Norfolk, Suffolk
MA 05	Barnstable, Bristol, Dukes, Nantucket, Plymouth
MA 06	Area is not defined. All of Essex and Middlesex counties are included in MA 03.
NM 01	All counties in New Mexico (includes NM 02).
UT 01	All counties in Utah (includes UT 02).

Figure I. Health service areas in the Eastern United States

Figure II. Health service areas in the Midwestern United States

Figure III. Health service areas in the Western United States

Appendix II. Variance formulas

This appendix derives the variance formulas for the expected neonatal mortality rate (ENMR) and the standardized mortality ratio (SMR). All terms in formulas should be interpreted as decimals, not rates (e.g., .012, not 12 per 1,000).

Let

B_i = number of births in weight i during year

$B = \sum B_i$

$p_i = B_i/B$

Since the ENMR reflects the birth weight distribution its variance is derived under a model which assumes that the B_i are the realization of a random process with underlying probability Π_i of a birth having weight i. Since birth certificates are sometimes sampled, we further allow that a simple random sample of b births are selected from the B births.

The variance of the SMR is derived conditionally upon the B_i since the SMR is used to compare weight-specific mortality given the birth weight distribution.

ENMR

Consider the following model. The number of births in a given year (for a particular population) is B with B_i births in each birth weight category ($\sum B_i = B$). We view the B_i's as the realization of an underlying process with probability Π_i of a birth having weight i. Thus, $B_1, B_2, \ldots, B_k$ has a multinomial distribution with parameters $B, \Pi_1, \ldots, \Pi_k$.

Now suppose we take a simple random sample (without replacement) of the B births. Then $b_1, b_2, \ldots, b_k$ has a multivariate hypergeometric distribution with parameters $b, p_1, \ldots, p_k$. It follows that conditional on $B_1, \ldots, B_k$,

$$E(b_i|B_i) = bp_i$$

$$\text{Var}\,(b_i|B_i) = \frac{B-b}{B-1}\,bp_iq_i \quad (q_i = 1 - p_i)$$

$$\text{cov}\,(b_i, b_j|B_i) = \frac{B-b}{B-1}\,p_ip_j$$

Suppose we wish to summarize the weight distribution by estimating the expected neonatal death rate that would occur given a standard set of weight-specific mortality rates $M_1, \ldots, M_k$. This can be written as

$$\text{ENMR} = \frac{1}{b}\sum b_iM_i \tag{1}$$

Conditionally on the B_i, the expected value of ENMR is

$$E(\text{ENMR}\,|B_i) = \sum p_iM_i \tag{2}$$

and it follows that (unconditionally)

$$E(\text{ENMR}) = \sum \Pi_iM_i \tag{3}$$

The conditional variance of M is

$$\text{Var}\,(\text{ENMR}\,|B_i) = \frac{B-b}{b(B-1)}\left\{\sum M_i^2p_iq_i - 2\sum_{i<j}M_iM_jp_ip_j\right\} \tag{4}$$

A general formula for the unconditional variance is

$$\text{Var}(\text{ENMR}) = E(\text{Var}(\text{ENMR}\,|B_i)) + \text{Var}(E(\text{ENMR}\,|B_i)) \tag{5}$$

The last term on the right is obtained from (2) as

$$\text{Var}(E(\text{ENMR}\,|B_i)) = \frac{1}{B}\left\{\sum M_i^2\Pi_i(1-\Pi_i) - 2\sum_{i<j}M_iM_j\Pi_i\Pi_j\right\} \tag{6}$$

In order to obtain the expected value of (4) note that

$$E(p_iq_i) = E(p_i - p_i^2) = \Pi_i(1 - \Pi_i)\left(1 - \frac{1}{B}\right)$$

$$E(p_ip_j) = -\frac{\Pi_i\Pi_j}{B} + \Pi_i\Pi_j = \Pi_i\Pi_j\left(1 - \frac{1}{B}\right)$$

Then

$$E(\text{Var}(\text{ENMR}|B_i)) = \frac{B - b}{b(B - 1)}\,\frac{B - 1}{b}$$

$$\left\{\sum M_i^2\Pi_i(1 - \Pi_i) - 2\sum_{i<j} M_iM_j\Pi_i\Pi_j\right\} \qquad (7)$$

Combining (6) and (7) gives

$$\text{Var}(\text{ENMR}) = \frac{1}{b}\left\{\sum M_i^2\Pi_i(1 - \Pi_i) - 2\sum_{i<j} M_iM_j\Pi_i\Pi_j\right\}$$

A convenient method of calculating Var(ENMR) is obtained from the following identity. If $a = \sum W_iC_i$, then

$$\begin{aligned} a(1 - a) &= \left(\sum W_iC_i\right)\left(1 - \sum W_iC_i\right) = \sum W_iC_i \\ &\quad - \left(\sum W_iC_i\right)^2 = \sum W_iC_i - \left\{\sum W_i^2C_i^2\right. \\ &\quad \left. + 2\sum_{i<j} W_iW_jC_iC_j\right\} = \sum W_iC_i - \sum W_iC_i^2 \\ &\quad + \sum W_iC_i^2 - \sum W_i^2C_i^2 - 2\sum_{i<j} W_iW_jC_iC_j \\ &= \sum W_iC_i(1 - C_i) + \sum W_i(1 - W_i)C_i^2 \\ &\quad - 2\sum_{i<j} W_iW_jC_iC_j \end{aligned} \qquad (8)$$

Thus,

$$\text{Var}(\text{ENMR}) = \frac{1}{b}\left\{\left(\sum\Pi_iM_i\right)\left(1 - \sum\Pi_iM_i\right) - \sum\Pi_iM_i(1 - M_i)\right\} \qquad (9)$$

To estimate Var(ENMR) we substitute b_i/b for Π_i in (9):

$$\hat{V}(\text{ENMR}) = \frac{1}{b}\left\{\text{ENMR}(1 - \text{ENMR}) - \frac{1}{b}\sum b_iM_i(1 - M_i)\right\} \qquad (10)$$

Since relative values of ENMR's and SMR's are of primary interest, it is convenient to transform the ENMR to its logarithm. The use of a logarithmic transformation allows the ratio of two ENMR's or SMR's to be expressed as the difference in their logarithms. The variance of the difference between two independent measures is then the sum of the two variances. Confidence intervals or significance tests based on the logarithmic transformation also have the advantage of being independent of which area is chosen for the denominator of the ratio.

An approximate formula for the variance of the logarithm of a random variable X is

$$\text{Var}(\ln X) = \frac{\text{Var}(X)}{(E(X))^2} \qquad (11)$$

Apply this to (9) and simplifying gives

$$\hat{V}(\ln \text{ENMR}) = \frac{1}{b}\left(\frac{Q - \text{ENMR}}{\text{ENMR}}\right) \qquad (12)$$

where

$$Q = \frac{\sum b_iM_i^2}{\sum b_iM_i}$$

SMR

All variance formulas derived here are conditional upon B_i. Let m_i denote the underlying mortality rate for weight i and let D be the observed number of neonatal deaths. Then D/B is the estimated NMR, and NMR/ENMR is the estimated SMR.

Let

$$L = \ln \text{SMR} = \ln \text{NMR} - \ln \text{ENMR} \qquad (13)$$

Then

$$\text{Var}(L|B_i) = \text{Var}(\ln \text{NMR}|B_i) + \text{Var}(\ln \text{ENMR}|B_i) \qquad (14)$$

Since these variances are conditional upon B_i the (conditional) covariance between NMR and ENMR is zero.

Note that

$$\text{NMR} = \frac{D}{B} = \frac{1}{B}\sum D_i \qquad (15)$$

where D_i is the number of deaths which occurred in weight i. Now

$$E(\text{NMR}|B_i) = \frac{1}{B}\sum m_iB_i$$

$$\text{Var}(\text{NMR}|B_i) = \frac{1}{B^2}\sum m_i(1 - m_i)B_i \qquad (16)$$

and using (11) we obtain

$$\text{Var}(\ln \text{NMR}\,|B_i) = \frac{\sum m_i(1 - m_i)B_i}{\left(\sum m_i B_i\right)^2} = \frac{1}{\sum m_i B_i}\left(1 - \frac{\sum B_i m_i^2}{\sum B_i m_i}\right) \quad (17)$$

Since the D_i are unknown when linked birth and death records are unavailable, there is no way to estimate the m_i.

It has been shown, however, that substitution of the standard set of rates for m_i in the expression

$$\frac{\sum B_i m_i^2}{\sum B_i m_i}$$

is a reasonable approximation.[13] Thus an estimate of the variance is:

$$\hat{V}(\ln \text{NMR}\,|B_i) = \frac{1}{D}\left(1 - \frac{\sum b_i M_i^2}{\sum b_i M_i}\right) = \frac{1}{D}(1 - Q) \quad (18)$$

Using equation (4) and the identity (8) we obtain (conditional on B_i)

$$\text{Var}(\text{ENMR}\,|B_i) = \frac{B - b}{b(B - 1)}\left\{\left(\sum p_i M_i\right)\left(1 - \sum p_i M_i\right) - \sum p_i M_i(1 - M_i)\right\} \quad (19)$$

To estimate this quantity we substitute b_i/b for p_i:

$$\hat{V}(\text{ENMR}\,|B_i) = \frac{B - b}{b(B - 1)}\left\{\sum \frac{b_i}{b} M_i^2 - \text{ENMR}^2\right\} \quad (20)$$

and

$$\hat{V}(\ln \text{ENMR}\,|B_i) = \frac{B - b}{b(B - 1)}\left(\frac{Q - \text{ENMR}}{\text{ENMR}}\right) \quad (21)$$

Finally,

$$\hat{V}(L\,|B_i) = \frac{1}{D}(1 - Q) + \frac{B - b}{b(B - 1)}\left(\frac{Q - \text{ENMR}}{\text{ENMR}}\right) \quad (22)$$

If the birth records are not sampled, $b = B$ and the last term becomes zero. Furthermore, the last term is closely related to the estimate of the unconditional variance of the ENMR. If, for example, 50 percent of birth records are sampled, then the last term in (22) is half of (12) (since $B - 1$ is very close to B).

When the SMR is modified to exclude births and deaths with birth weight below 500 grams, the formulas given above are still applicable as long as this category is excluded from D, Q, B, b, and ENMR.

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